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Jon W Dudas

Acting Under Secretary of Commerce
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16367 U.S. PTO

PTO/SB/16 (08-03)

Approved for use through 07/31/2006. OMB 0651-0032

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

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010904

INVENTOR(S)					
Given Name (first and middle [if any])		Family Name or Surname		Residence (City and either State or Foreign Country)	
Lynne Canne		Bannen		Pacifica, California	
Diva Sze-Ming		Chan		San Francisco, California	
<input checked="" type="checkbox"/> Additional inventors are being named on the <u>1</u> separately numbered sheets attached hereto					
TITLE OF THE INVENTION (500 characters max)					
c-Met Modulators and Method of Use					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
<input checked="" type="checkbox"/> Customer Number 					
OR					
<input type="checkbox"/> Firm or Individual Name					
Address					
Address					
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ENCLOSED APPLICATION PARTS (check all that apply)					
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<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.					
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees					
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FILING FEE AMOUNT (\$) 160					
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
<input checked="" type="checkbox"/> No.					
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: <u> </u>					

Respectfully submitted

SIGNATURE

(Page 1 of 2)

Date

01/09/04

TYPED or PRINTED NAME

Brian D. Griedel

REGISTRATION NO.
(if appropriate)

48,425

Docket Number:

EX04-001P

TELEPHONE

650.837.8326

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Docket Number EX04-001P

INVENTOR(S)/APPLICANT(S)		
Given Name (first and middle (if any))	Family or Surname	Residence (City and either State or Foreign Country)
Lisa E.	Dalrymple	San Francisco, California
Richard George	Khoury	Redwood City, California
James W.	Leahy	San Leandro, California
Morrison B.	Mac	San Francisco, California
Grace	Mann	Brisbane, California
Larry W.	Mann	Redwood City, California
John M.	Nuss	Danville, California
Jason Jevious	Parks	Sacramento, California
Yong	Wang	South San Francisco, California
Wei	Xu	Danville, California

[Page 2 of 2]

Number 1 of 1

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PROVISIONAL PATENT APPLICATION

c-Met Modulators and Method of Use

Inventors: Lynne Canne Bannen
801 St. Lawrence Drive
Pacifica, CA 94044
United States Citizen

Grace Mann
231 Callippe Court
Brisbane, CA 94005
United States Citizen

Diva Sze-Ming Chan
1775 46th Avenue
San Francisco, CA 94122
United States Citizen

Larry W. Mann
780 Blair Island Road, Apt. 304
Redwood City, CA 94063
United States Citizen

Lisa E. Dalrymple
387 17th Avenue
San Francisco, CA 94121
United States Citizen

John M. Nuss
16 Woodranch Circle
Danville, CA 94506
United States Citizen

Richard George Khoury
225 Poseidon Lane
Redwood City, CA 94065
United States Citizen

Jason Jevious Parks
5 Bethesda Court
Sacramento, CA 95838
United States Citizen

James W. Leahy
1185 Camellia Court
San Leandro, CA 94577
United States Citizen

Yong Wang
170 Harbor Way
South San Francisco, CA 94080
People's Republic of China

Morrison B. Mac
2567 30th Avenue
San Francisco, CA 94116
United States Citizen

Wei Xu
327 Glasgow Circle
Danville, CA 94526
United States Citizen

Assignee: Exelixis, Inc.

Entity: Large

c-Met Modulators and Method of Use

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to compounds for modulating protein kinase enzymatic activity for modulating cellular activities such as proliferation, differentiation, programmed cell death, migration and chemoinvasion. Even more specifically, the invention relates to quinazolines and quinolines which inhibit, regulate and/or modulate kinase receptor signal transduction pathways related to the changes in cellular activities as mentioned above, compositions which contain these compounds, and methods of using them to treat kinase-dependent diseases and conditions.

Summary of Related Art

[0002] Improvements in the specificity of agents used to treat cancer is of considerable interest because of the therapeutic benefits which would be realized if the side effects associated with the administration of these agents could be reduced. Traditionally, dramatic improvements in the treatment of cancer are associated with identification of therapeutic agents acting through novel mechanisms.

[0003] Protein kinases are enzymes that catalyze the phosphorylation of proteins, in particular, hydroxy groups on tyrosine, serine and threonine residues of proteins. The consequences of this seemingly simple activity are staggering; cell differentiation and proliferation; i.e., virtually all aspects of cell life in one-way or another depend on protein kinase activity. Furthermore, abnormal protein kinase activity has been related to a host of disorders, ranging from relatively non-life threatening diseases such as psoriasis to extremely virulent diseases such as glioblastoma (brain cancer).

[0004] Protein kinases can be categorized as receptor type or non-receptor type. Receptor-type tyrosine kinases have an extracellular, a transmembrane, and an intracellular portion, while non-receptor type tyrosine kinases are wholly intracellular.

[0005] Receptor-type tyrosine kinases are comprised of a large number of transmembrane receptors with diverse biological activity. In fact, about 20 different subfamilies of receptor-

type tyrosine kinases have been identified. One tyrosine kinase subfamily, designated the HER subfamily, is comprised of EGFR (HER1), HER2, HER3, and HER4. Ligands of this subfamily of receptors identified so far include epithelial growth factor, TGF-alpha, amphiregulin, HB-EGF, betacellulin and heregulin. Another subfamily of these receptor-type tyrosine kinases is the insulin subfamily, which includes INS-R, IGF-IR, and IR-R. The PDGF subfamily includes the PDGF-alpha and beta receptors, CSFIR, c-Kit and FLK-II. Then there is the FLK family, which is comprised of the kinase insert domain receptor (KDR), fetal liver kinase-1 (FLK-1), fetal liver kinase-4 (FLK-4) and the fms-like tyrosine kinase-1 (flt-1). The PDGF and FLK families are usually considered together due to the similarities of the two groups. For a detailed discussion of the receptor-type tyrosine kinases, see Plowman et al., DN&P 7(6): 334-339, 1994, which is hereby incorporated by reference.

[0006] The non-receptor type of tyrosine kinases is also comprised of numerous subfamilies, including Src, Frk, Btk, Csk, Abl, Zap70, Fes/Fps, Fak, Jak, Ack, and LIMK. Each of these subfamilies is further sub-divided into varying receptors. For example, the Src subfamily is one of the largest and includes Src, Yes, Fyn, Lyn, Lck, Blk, Hck, Fgr, and Yrk. The Src subfamily of enzymes has been linked to oncogenesis. For a more detailed discussion of the non-receptor type of tyrosine kinases, see Bolen, *Oncogene*, 8:2025-2031 (1993), which is hereby incorporated by reference.

[0007] Since protein kinases and their ligands play critical roles in various cellular activities, deregulation of protein kinase enzymatic activity can lead to altered cellular properties, such as uncontrolled cell growth associated with cancer. In addition to oncological indications, altered kinase signaling is implicated in numerous other pathological diseases. These include, but are not limited to: immunological disorders, cardiovascular diseases, inflammatory diseases, and degenerative diseases. Therefore, both receptor and non-receptor protein kinases are attractive targets for small molecule drug discovery.

[0008] One particularly attractive goal for therapeutic use of kinase modulation relates to oncological indications. For example, modulation of protein kinase activity for the treatment of cancer has been demonstrated successfully with the FDA approval of Gleevec® (imatinib mesylate, produced by Novartis Pharmaceutical Corporation of East Hanover, NJ) for the treatment of Chronic Myeloid Leukemia (CML) and gastrointestinal stroma cancers (GIST). Gleevec is a c-Kit and Abl kinase inhibitor.

- [0009] Modulation (particularly inhibition) of cell proliferation and angiogenesis, two key cellular processes needed for tumor growth and survival (Matter A. Drug Disc Technol 2001 6, 1005-1024), is an attractive goal for development of small-molecule drugs. Anti-angiogenic therapy represents a potentially important approach for the treatment of solid tumors and other diseases associated with dysregulated vascularization, including ischemic coronary artery disease, diabetic retinopathy, psoriasis and rheumatoid arthritis. As well, cell antiproliferative agents are desirable to slow or stop the growth of tumors.
- [0010] One particularly attractive target for small-molecule modulation, with respect to antiangiogenic and antiproliferative activity is c-Met. The kinase, c-Met, is the prototypic member of a subfamily of heterodimeric receptor tyrosine kinases (RTKs) which include Met, Ron and Sea. Expression of c-Met occurs in a wide variety of cell types including epithelial, endothelial and mesenchymal cells where activation of the receptor induces cell migration, invasion, proliferation and other biological activities associated with "invasive cell growth." As such, signal transduction through c-Met receptor activation is responsible for many of the characteristics of tumor cells.
- [0011] The endogenous ligand for c-Met is the hepatocyte growth factor (HGF), a potent inducer of angiogenesis, also known as "scatter factor" (SF). Binding of HGF to c-Met induces activation of the receptor via autophosphorylation resulting in an increase of receptor dependent signaling, which promotes cell growth and invasion. Anti-HGF antibodies or HGF antagonists have been shown to inhibit tumor metastasis *in vivo* (See: Maulik et al Cytokine & Growth Factor Reviews 2002 13, 41-59).
- [0012] Tumor growth progression requires the recruitment of new blood vessels into the tumor from preexisting vessels as well as invasion, adhesion and proliferation of malignant cells. Accordingly, c-Met overexpression has been demonstrated on a wide variety of tumor types including breast, colon, renal, lung, squamous cell myeloid leukemia, hemangiomas, melanomas, astrocytomas, and glioblastomas. Additionally activating mutations in the kinase domain of c-Met have been identified in hereditary and sporadic renal papilloma and squamous cell carcinoma. (See: Maulik et al Cytokine & growth Factor reviews 2002 13, 41-59; Longati et al Curr Drug Targets 2001, 2, 41-55; Funakoshi et al Clinica Chimica Acta 2003 1-23). Thus modulation of c-Met is desirable as a means to treat cancer and cancer-related disease.

- [0013] The Eph receptors comprise the largest family of receptor tyrosine kinases and are divided into two groups, EphA and EphB, based on their sequence homology. The ligands for the Eph receptors are ephrin, which are membrane anchored. Ephrin A ligands bind preferentially to EphA receptors whilst ephrin B ligands bind to EphB receptors. Binding of ephrin to Eph receptors causes receptor autophosphorylation and typically requires a cell-cell interaction since both receptor and ligand are membrane bound.
- [0014] Overexpression of Eph receptors has been linked to increased cell proliferation in a variety of tumors (Zhou R 1998 Pharmacol Ther. 77, 151-181; Kiyokawa E, Takai S, Tanaka M et al 1994 Cancer Res 54, 3645-3650; Takai N Miyazaki T, Fujisawa K, Nasu K and Miyakawa. 2001 Oncology reports 8, 567-573). The family of Eph receptor tyrosine kinases and their ephrin ligands play important roles in a variety of processes during embryonic development and also in pathological angiogenesis and potentially metastasis. Therefore modulation of Eph receptor kinase activity should provide means to treat or prevent disease states associated with abnormal cell proliferation such as those described above.
- [0015] Inhibition of EGF, VEGF and ephrin signal transduction will prevent cell proliferation and angiogenesis, two key cellular processes needed for tumor growth and survival (Matter A. Drug Disc. Technol. 2001 6, 1005-1024). EGF and VEGF receptors are previously described targets for small molecule inhibition. KDR and flt-4 are both VEGF receptors
- [0016] One particularly attractive target for small-molecule modulation is c-Kit. The proto-oncogene *c-Kit* was first identified as the oncogenic component of the acutely transforming Hardy-Zuckerman 4-feline sarcoma virus (Besmer et al Nature 1986 320:415-421). c-Kit (also called stem cell factor receptor or steel factor receptor) is a type 3 receptor tyrosine kinase (RTK) belonging to the platelet-derived growth factor receptor subfamily. c-Kit binds the ligand stem cell factor (SCF), and triggers its multiple signal transduction pathways including Src family kinases, phosphatidyl-inositol 3 kinase, the Ras-Raf-Map kinase cascade, and phospholipase C (Broudy et al Blood 1999 94: 1979-1986; Lennartsson et al Oncogene 1999 18: 5546-5553 ; Timokhina et al EMBO J 1998 17:6250-6262; Chian et al Blood 2001 98(5):1365-1373; Blume-Jensen et al Curr Biol 1998 8:779-782; Kissel et al EMBO J 2000 19:1312-1326; Lennartsson et al. Oncogene 1999 18: 5546-5553; Sue et al Blood, 1998; 92:1242-1149; Lev et al EMBO J 1991 10:647-654). c-Kit is required for normal hematopoiesis, melanogenesis, and gametogenesis. c-Kit is expressed in mast cells, immature myeloid cells, melanocytes, epithelial breast cells and the interstitial cells of Cajal

(ICC). In mast cells, it is required not only for the differentiation, maturation, chemotaxis, and haptotaxis but also for the promotion of survival and proliferation.

[0017] Mutations in c-Kit have been implicated in human disease. Mutations in the juxtamembrane domain are found in many human gastrointestinal stromal tumors, and mutations in the kinase domain are found in mastocytosis, germ cell tumors, acute myeloid leukemia (AML), NK lymphoma, and other hematologic disorders (Hirota et al Science 1998 279:577-580; Singer et al J Clin Oncol 2002 20:3898-3905; Longley et al Proc Natl Aca Sci USA 1999: 1609-1614; Tian et al Am J Pathol 1999 154: 1643-1647; Beghini et al Blood 2000 95:726-727; Hongyo et al Cancer Res 2000 60:2345-2347). These mutations result in ligand-independent tyrosine kinase activity, autophosphorylation of c-Kit, uncontrolled cell proliferation, and stimulation of downstream signaling pathways. Overexpression of c-Kit and c-Kit ligand have also been described in other tumors including small-cell lung cancer, neuroblastomas, gynecological tumors, and colon carcinoma, which might result in autocrine or paracrine c-Kit activation.

[0018] The overexpression of c-Kit has also been implicated in the development of neoplasia associated with neurofibromatosis type 1 (NF1). Mutations in the tumor suppressor gene *NF1* lead to a deficiency in neurofibromin, a GTPase-activating protein for Ras. This deficiency results in abnormal proliferation of Schwann cells in the peripheral nervous system, and predisposes affected individuals to peripheral nerve sheath tumors (neurofibromas), astrocytomas (optic pathway gliomas), learning disabilities, seizures, strokes, macrocephaly, vascular abnormalities, and juvenile myelomonocytic leukemia (Lynch & Gutmann Neurol Clin 2002 20:841-865). Genetic experiments in mice demonstrate that haploinsufficiency at *NF1* partially rescues some of the phenotypes associated with mutations in the gene for c-Kit, indicating that these genes function along a common developmental pathway (Ingram, et al. J. Exp Med 2000 191:181-187). Also, c-Kit is expressed in schwannoma cells from NF1 patients, but not in normal schwann cells (Ryan et al. J Neurosci Res 1994 37:415-432). These data indicate that elevated c-Kit expression and sensitivity to stem cell factor may play important roles in the development of proliferative disorders associated with NF-1. Therefore, c-Kit inhibitors may be effective chemotherapeutic agents for treating patients with NF-1.

[0019] GISTs are the most common mesenchymal tumors of the gastrointestinal tract, and they are generally resistant to chemotherapy and radiation therapy. However, recent results with the c-Kit/BCR-Abl inhibitor STI571 indicate that targeting c-Kit may be an effective

therapeutic strategy for this disease (Eisenberg & Mehren Expert Opin Pharmacother 2003 4:869-874). Malignant mast cell disease often suggests an extremely poor prognosis, and no reliable effective chemotherapeutic agents have been identified (Marone et al Leuk Res 2001 25:583-594). Systemic mast cell disorders have been treated with interferon-alpha, although the effectiveness of this therapy has been variable (Lehmann & Lammle Ann Hematol 1999 78:483-484; Butterfield Br J Dermatol 1998 138: 489-495). Therefore, activated c-Kit might serve as a therapeutic target in GISTs and mast cell disease, as well as other disorders associated with activated c-Kit.

[0020] Flt-3 is normally expressed on hematopoietic progenitor cells and a subset of mature myeloid and lymphoid cells, where it modulates cell survival and proliferation. Flt-3 is constitutively activated via mutation, either in the juxtamembrane region or in the activation loop of the kinase domain, in a large proportion of patients with AML (Reilly Leuk Lymphoma 2003 44: 1-7). Also, mutations in flt-3 are significantly correlated with poor prognosis in AML patients (Sawyers Cancer Cell 2002 1: 413-415).

[0021] Accordingly, the identification of small-molecule compounds that specifically inhibit, regulate and/or modulate the signal transduction of kinases, particularly including c-Met, KDR, c-Kit, flt-3, and flt-4, is desirable as a means to treat or prevent disease states associated with abnormal cell proliferation and angiogenesis, and is an object of this invention.

SUMMARY OF THE INVENTION

[0022] In one aspect, the present invention provides compounds for modulating kinase activity and methods of treating diseases mediated by kinase activity utilizing the compounds and pharmaceutical compositions thereof. Diseases mediated by kinase activity include, but are not limited to, diseases characterized in part by migration, invasion, proliferation and other biological activities associated with invasive cell growth. In particular to this invention is modulation, even more particularly inhibition, of c-Met, KDR, c-Kit, flt-3, and flt-4,

[0023] In another aspect, the invention provides methods of screening for modulators of c-Met, KDR, c-Kit, flt-3, and flt-4 activity. The methods comprise combining a composition of the invention, a kinase, e.g. c-Met, KDR, c-Kit, flt-3, or flt-4, and at least one candidate agent and determining the effect of the candidate agent on the c-Met, KDR, c-Kit, flt-3, or flt-4, activity.

[0024] In yet another aspect, the invention also provides pharmaceutical kits comprising one or more containers filled with one or more of the ingredients of pharmaceutical compounds and/or compositions of the present invention, including, one or more kinase, e.g. c-Met, KDR, c-Kit, flt-3, or flt-4, enzyme activity modulators as described herein. Such kits can also include, for example, other compounds and/or compositions (e.g., diluents, permeation enhancers, lubricants, and the like), a device(s) for administering the compounds and/or compositions, and written instructions in a form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which instructions can also reflect approval by the agency of manufacture, use or sale for human administration.

[0025] In still yet another aspect, the invention also provides a diagnostic agent comprising a compound of the invention and, optionally, pharmaceutically acceptable adjuvants and excipients.

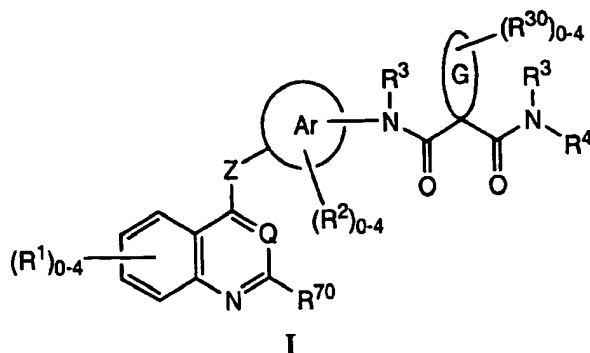
[0026] These and other features and advantages of the present invention will be described in more detail below with reference to the associated drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0027] The compositions of the invention are used to treat diseases associated with abnormal and or unregulated cellular activities. Disease states which can be treated by the methods and compositions provided herein include, but are not limited to, cancer (further discussed below), immunological disorders such as rheumatoid arthritis, graft-host diseases, multiple sclerosis, psoriasis; cardiovascular diseases such as arteriosclerosis, myocardioinfarction, ischemia, stroke and restenosis; other inflammatory and degenerative diseases such as interbowel diseases, osteoarthritis, macular degeneration, diabetic retinopathy.

[0028] It is appreciated that in some cases the cells may not be in a hyper- or hypo-proliferative and/or migratory state (abnormal state) and still require treatment. For example, during wound healing, the cells may be proliferating "normally", but proliferation and migration enhancement may be desired. Alternatively, reduction in "normal" cell proliferation and/or migration rate may be desired.

[0029] The present invention comprises a compound for modulating kinase activity according to Formula I,



or a pharmaceutically acceptable salt, hydrate, or prodrug thereof, wherein,

each R^1 is independently selected from halogen, $-OR^3$, $-NO_2$, $-NH_2$, $-NR^3R^4$, $-D-R^{50}$ and optionally substituted C_{1-6} alkyl;

R^{70} is selected from $-H$, halogen, $-OR^3$, $-S(O)_{0-2}R^3$, $-NO_2$, $-NH_2$, $-NR^3R^4$, and optionally substituted C_{1-6} alkyl;

Q is selected from $=N-$, $=C(H)-$, and $=C(CN)-$;

Z is selected from $-S(O)_{0-2}-$, $-O-$, and $-NR^5-$;

Ar is either a five- or six-membered arylene or a five- or six-membered heteroarylene containing between one and three heteroatoms;

G is either an optionally substituted cycloalkyl or an optionally substituted heteroalicyclic;

each R^2 is independently selected from halogen, trihalomethyl, $-CN$, $-NO_2$, $-NH_2$, $-OR^3$, $-NR^3R^4$, $-S(O)_{0-2}R^3$, $-SO_2NR^3R^3$, $-CO_2R^3$, $-C(O)NR^3R^3$, $-N(R^3)SO_2R^3$, $-N(R^3)C(O)R^3$, $-N(R^3)CO_2R^3$, $-C(O)R^3$, and optionally substituted C_{1-6} alkyl;

each R^3 is independently $-H$ or R^4 ;

each R^4 is independently selected from optionally substituted C_{1-6} alkyl, optionally substituted aryl, optionally substituted aryl C_{1-6} alkyl, optionally substituted heterocyclyl, and optionally substituted heterocyclyl C_{1-6} alkyl; or

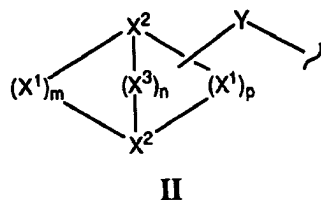
R^3 and R^4 , when taken together with a common nitrogen to which they are attached, form an optionally substituted five- to seven-membered heterocyclyl, said optionally substituted five-

to seven-membered heterocyclyl optionally containing at least one additional annular heteroatom selected from N, O, S, and P;

R^5 is -H or optionally substituted C_{1-6} alkyl;

each D is independently selected from -O-, $-S(O)_{0-2}-$, and $-NR^5-$;

each R^{50} is independently either R^3 , or according to formula II;



wherein X^1 , X^2 , and optionally X^3 , represent the atoms of a saturated bridged ring system, said saturated bridged ring system comprising up to four annular heteroatoms represented by any of X^1 , X^2 , and X^3 ; wherein,

each X^1 is independently selected from $-C(R^6)R^7-$, -O-, $-S(O)_{0-2}-$, and $-NR^8-$;

each X^2 is independently an optionally substituted bridgehead methine or a bridgehead nitrogen;

each X^3 is independently selected from $-C(R^6)R^7-$, -O-, $-S(O)_{0-2}-$, and $-NR^8-$;

Y is either:

an optionally substituted lower alkylene linker, between D and either 1) any annular atom of the saturated bridged ring system, except X^2 when X^2 is a bridgehead nitrogen, or 2) any heteroatom, represented by any of R^6 or R^7 ; provided there are at least two carbon atoms between D and any annular heteroatom of the saturated bridged ring system or any heteroatom represented by any of R^6 or R^7 ;

or Y is absent, when Y is absent, said saturated bridged ring system, is directly attached to D via an annular carbon of said saturated bridged ring system, unless D is $-SO_2-$, in which case said saturated bridged ring system, is directly attached to D via an any annular atom of said saturated bridged ring system;

m and p are each independently one to four;

n is zero to two, when n equals zero, then there is a single bond between the two bridgehead X^2 's;

R^6 and R^7 are each independently selected from -H, halogen, trihalomethyl, -CN, -NH₂, -NO₂, -OR³, -NR³R⁴, -S(O)₀₋₂R⁴, -SO₂NR³R⁴, -CO₂R³, -C(O)NR³R⁴, -N(R³)SO₂R⁴, -N(R³)C(O)R³, -NCO₂R³, -C(O)R³, optionally substituted C₁₋₆alkyl, optionally substituted aryl, optionally substituted aryl C₁₋₆alkyl, optionally substituted heterocyclyl, optionally substituted heterocyclyl C₁₋₆alkyl, and a bond to either Y or D; or

R^6 and R^7 , when taken together are oxo; or

R^6 and R^7 , when taken together with a common carbon to which they are attached, form a optionally substituted three- to seven-membered spirocyclyl, said optionally substituted three- to seven-membered spirocyclyl optionally containing at least one additional annular heteroatom selected from N, O, S, and P;

R^8 is selected from -R³, Y, -SO₂NR³R⁴, -CO₂R⁴, -C(O)NR³R³, -SO₂R⁴, and -C(O)R³; and

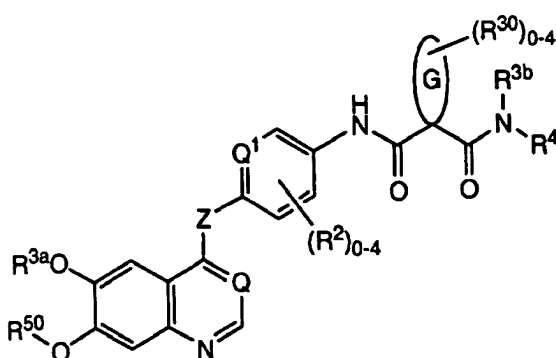
each R^{30} is independently selected from halogen, trihalomethyl, -CN, -NO₂, -NH₂, -OR³, -NR³R⁴, -S(O)₀₋₂R³, -SO₂NR³R³, -CO₂R³, -C(O)NR³R³, -N(R³)SO₂R³, -N(R³)C(O)R³, -N(R³)CO₂R³, -C(O)R³, and optionally substituted C₁₋₆alkyl.

[0030] In one example, the compound is according to paragraph [0029], wherein Z is either -O- or -NR⁵-.

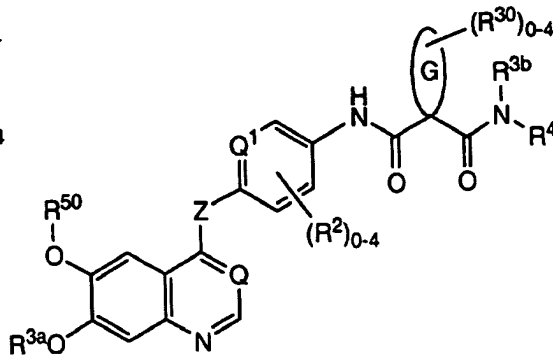
[0031] In another example, the compound is according to paragraph [0030], wherein at least one of R^1 is -D-R⁵⁰.

[0032] In another example, the compound is according to paragraph [0031], wherein D is -O- and at least one other R^1 is -OR³.

[0033] In another example, the compound is according to paragraph [0032], of formula **IIIa** or **IIIb**:



IIIa



IIIb

wherein Q^1 is either =N- or =C(H)-.

[0034] In another example, the compound is according to paragraph [0033], wherein R^{50} is selected from C_{1-6} alkyl optionally substituted with at least one of optionally substituted amino, optionally substituted C_{1-6} alkyl amino, optionally substituted C_{1-6} dialkyl amino, optionally substituted heteroalicyclic, and a group of formula II.

[0035] In another example, the compound is according to paragraph [0034], wherein R^{3a} is C_{1-6} alkyl.

[0036] In another example, the compound is according to paragraph [0035], wherein Z is -O-.

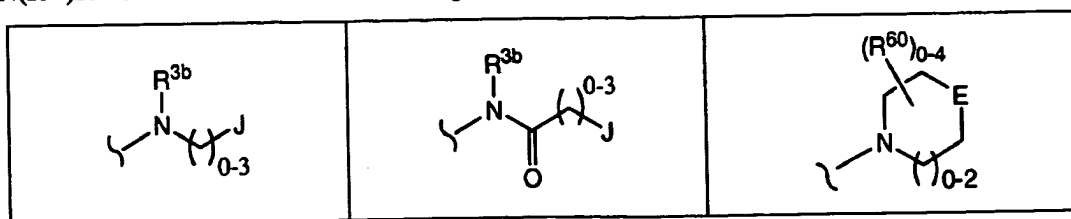
[0037] In another example, the compound is according to paragraph [0036], wherein G is cyclopropyl, optionally substituted with between zero and four of R^{30} .

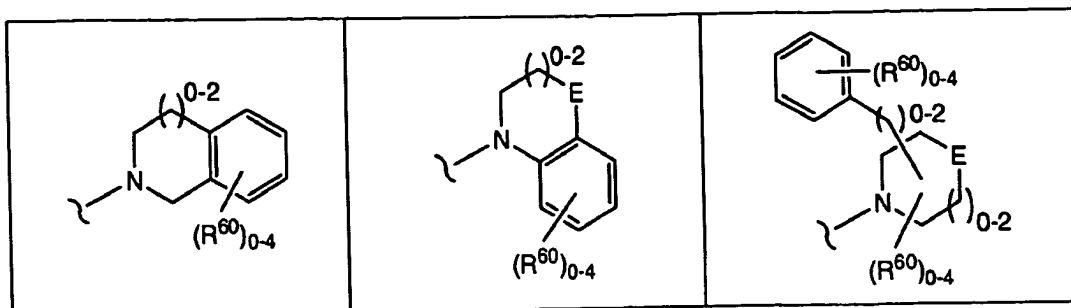
[0038] In another example, the compound is according to paragraph [0037], wherein Q is either =N- or =C(H)-.

[0039] In another example, the compound is according to paragraph [0038], wherein at least one of R^2 is halogen.

[0040] In another example, the compound is according to paragraph [0038], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0041] In another example, the compound is according to paragraph [0038], wherein $-N(R^{3b})R^4$ is selected from the following:





wherein J, is a five- to ten-membered ring, optionally substituted with between zero and five of R^{20} ;

each R^{20} is independently selected from halogen, trihalomethyl, $-CN$, $-NO_2$, $-NH_2$, $-OR^3$, $-NR^3R^4$, $-S(O)_{0-2}R^3$, $-SO_2NR^3R^3$, $-CO_2R^3$, $-C(O)NR^3R^3$, $-N(R^3)SO_2R^3$, $-N(R^3)C(O)R^3$, $-N(R^3)CO_2R^3$, $-C(O)R^3$, and optionally substituted C_{1-6} alkyl;

E is selected from $-O-$, $-N(R^5)-$, $-CH_2-$, and $-S(O)_{0-2}-$;

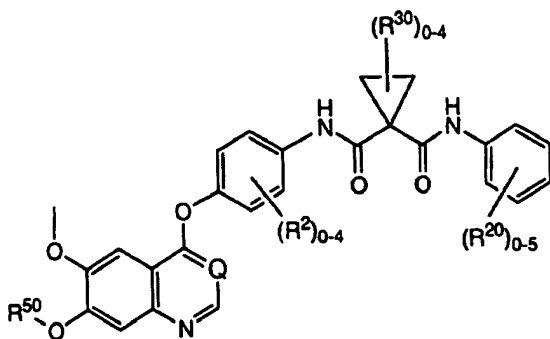
each R^{60} is independently selected from halogen, trihalomethyl, $-CN$, $-NO_2$, $-NH_2$, $-OR^3$, $-NR^3R^4$, $-S(O)_{0-2}R^3$, $-SO_2NR^3R^3$, $-CO_2R^3$, $-C(O)NR^3R^3$, $-N(R^3)SO_2R^3$, $-N(R^3)C(O)R^3$, $-N(R^3)CO_2R^3$, $-C(O)R^3$, optionally substituted C_{1-6} alkyl, optionally substituted aryl, optionally substituted heteroaryl C_{1-6} alkyl, and optionally substituted aryl C_{1-6} alkyl;

each methylene in any of the above formulae, other than those in a depicted ring, is independently optionally substituted with R^{25} ; and

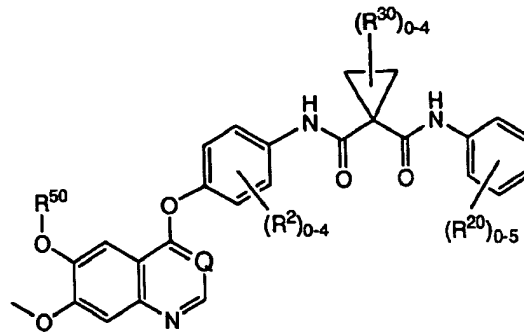
R^{25} is selected from halogen, trihalomethyl, oxo, $-CN$, $-NO_2$, $-NH_2$, $-OR^3$, $-NR^3R^4$, $-S(O)_{0-2}R^3$, $-SO_2NR^3R^3$, $-CO_2R^3$, $-C(O)NR^3R^3$, $-N(R^3)SO_2R^3$, $-N(R^3)C(O)R^3$, $-N(R^3)CO_2R^3$, $-C(O)R^3$, optionally substituted aryl, optionally substituted aryl C_{1-6} alkyl, heteroaryl C_{1-6} alkyl, and optionally substituted C_{1-6} alkyl; or

two of R^{25} , together with the carbon or carbons to which they are attached, can combine to form a three- to seven-membered alicyclic or heteroalicyclic.

[0042] In another example, the compound is according to paragraph [0041], of formula IVa or IVb:



IVa



IVb

[0043] In another example, the compound is according to paragraph [0042], wherein R^{50} is C_{1-6} alkyl optionally substituted with an optionally substituted heteroalicyclic.

[0044] In another example, the compound is according to paragraph [0043], wherein the heteroalicyclic portion of said optionally substituted heteroalicyclic of R^{50} is selected from the group consisting of piperidine, piperazine, morpholine, thiomorpholine, thiomorpholine 1-oxide, thiomorpholine 1,1-dioxide, 2-oxo-morpholine, pyrrolidine, and azepine.

[0045] In another example, the compound is according to paragraph [0044], wherein at least one of R^2 is halogen.

[0046] In another example, the compound is according to paragraph [0044], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0047] In another example, the compound is according to paragraph [0045], wherein at least one of R^{20} is halogen.

[0048] In another example, the compound is according to paragraph [0047], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

[0049] In another example, the compound is according to paragraph [0042], wherein R^{50} is according to formula II.

[0050] In another example, the compound is according to paragraph [0049], wherein the saturated bridged ring system according to formula II has a geometry selected from the group consisting of [4.4.0], [4.3.0], [4.2.0], [4.1.0], [3.3.0], [3.2.0], [3.1.0], [3.3.3], [3.3.2], [3.3.1], [3.2.2], [3.2.1], [2.2.2], and [2.2.1].

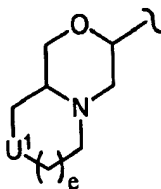
[0051] In another example, the compound is according to paragraph [0050], wherein Y is selected from $-CH_2CH_2CH_2CH_2-$, $-CH_2CH_2CH_2-$, $-CH_2CH_2-$, $-CH_2-$, and absent.

[0052] In another example, the compound is according to paragraph [0051], wherein $n = 0$ and the saturated bridged ring system according to formula II has a geometry selected from the group consisting of [4.4.0], [4.3.0], [4.2.0], [4.1.0], [3.3.0], [3.2.0], and [3.1.0].

[0053] In another example, the compound is according to paragraph [0052], wherein said saturated bridged ring system contains at least one annular nitrogen or at least one annular oxygen.

[0054] In another example, the compound is according to paragraph [0053], wherein said saturated bridged ring system contains $-NR^8-$, wherein R^8 is selected from $-H$, optionally substituted C_{1-6} alkyl, $-CO_2R^3$, $-C(O)NR^3R^3$, $-SO_2R^3$, and $-C(O)R^3$.

[0055] In another example, the compound is according to paragraph [0053], wherein said saturated bridged ring system is of formula V,



V

wherein U^1 is selected from $-O-$, $-S(O)_{0-2}-$, $-NR^8-$, $-CR^6R^7-$, and absent; and e is 0 or 1.

[0056] In another example, the compound is according to paragraph [0055], wherein Y is $-CH_2-$.

[0057] In another example, the compound is according to paragraph [0056], wherein at least one of R^2 is halogen.

[0058] In another example, the compound is according to paragraph [0056], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0059] In another example, the compound is according to paragraph [0057], wherein at least one of R^{20} is halogen.

[0060] In another example, the compound is according to paragraph [0059], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

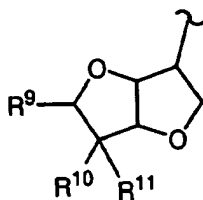
[0061] In another example, the compound is according to paragraph [0056], wherein U^1 is $-NR^8$ -, wherein R^8 is selected from $-H$, optionally substituted lower alkyl, $-CO_2R^3$, $-C(O)NR^3R^3$, $-SO_2R^3$, and $-C(O)R^3$.

[0062] In another example, the compound is according to paragraph [0056], wherein U^1 is $-O-$.

[0063] In another example, the compound is according to paragraph [0056], wherein U^1 is absent.

[0064] In another example, the compound is according to paragraph [0053], wherein Y is selected from $-CH_2CH_2-$, $-CH_2-$, and absent.

[0065] In another example, the compound is according to paragraph [0064], wherein said saturated bridged ring system is of formula VI,



VI

wherein R^9 , R^{10} , and R^{11} are each independently selected from $-H$, and $-OR^{12}$; or

R^9 is selected from $-H$, and $-OR^{12}$, and R^{10} and R^{11} , when taken together, are either an optionally substituted alkylidene or an oxo;

R^{12} is selected from $-H$, $-C(O)R^3$, optionally substituted lower alkylidyne, optionally substituted lower arylalkylidyne, optionally substituted lower heterocyclalkylidyne, optionally substituted lower alkylidene, optionally substituted lower alkylidenearyl, optionally substituted lower alkylideneheterocycl, optionally substituted lower alkyl, optionally substituted lower alkylaryl, optionally substituted aryl, optionally substituted lower heterocyclalkyl, and optionally substituted heterocycl;

or two R^{12} 's, when taken together, form 1) a corresponding spirocyclic ketal when said two R^{12} 's stem from R^{10} and R^{11} , or 2) a corresponding cyclic ketal when said two R^{12} 's stem from R^9 and one of R^{10} and R^{11} .

[0066] In another example, the compound is according to paragraph [0065], wherein at least one of R^2 is halogen.

[0067] In another example, the compound is according to paragraph [0065], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0068] In another example, the compound is according to paragraph [0066], wherein at least one of R^{20} is halogen.

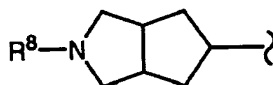
[0069] In another example, the compound is according to paragraph [0068], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

[0070] In another example, the compound is according to paragraph [0065], wherein one of R^{10} and R^{11} is $-OR^{12}$, wherein R^{12} is selected from $-H$, $-C(O)R^3$, and optionally substituted lower alkyl; and R^9 and the other of R^{10} and R^{11} are both $-H$.

[0071] In another example, the compound is according to paragraph [0070], wherein Y is either $-CH_2-$ or absent.

[0072] In another example, the compound is according to paragraph [0065], wherein R^9 is an alkyl group containing at least one fluorine substitution thereon.

[0073] In another example, the compound is according to paragraph [0054], wherein said saturated bridged ring system is of formula VII.



VII

[0074] In another example, the compound is according to paragraph [0073], wherein Y is either $-CH_2-$ or absent.

[0075] In another example, the compound is according to paragraph [0074], wherein R^8 is methyl or ethyl.

[0076] In another example, the compound is according to paragraph [0075], wherein at least one of R^2 is halogen.

[0077] In another example, the compound is according to paragraph [0075], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0078] In another example, the compound is according to paragraph [0076], wherein at least one of R^{20} is halogen.

[0079] In another example, the compound is according to paragraph [0078], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

[0080] In another example, the compound is according to paragraph [0054], wherein said saturated bridged ring system is of formula VIII.



VIII

[0081] In another example, the compound is according to paragraph [0080], wherein Y is $-\text{CH}_2-$.

[0082] In another example, the compound is according to paragraph [0081], wherein R^8 is methyl or ethyl.

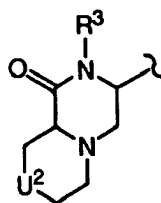
[0083] In another example, the compound is according to paragraph [0082], wherein at least one of R^2 is halogen.

[0084] In another example, the compound is according to paragraph [0082], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0085] In another example, the compound is according to paragraph [0083], wherein at least one of R^{20} is halogen.

[0086] In another example, the compound is according to paragraph [0085], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

[0087] In another example, the compound is according to paragraph [0053], wherein said saturated bridged ring system is of formula IX



IX

wherein U^2 is selected from -O-, $-S(O)_{0-2}-$, $-NR^8-$, $-CR^6R^7-$, and absent.

[0088] In another example, the compound is according to paragraph [0087], wherein R^3 of formula IX is selected from -H and optionally substituted alkyl.

[0089] In another example, the compound is according to paragraph [0088], wherein U^2 is either $-CR^6R^7-$ or absent.

[0090] In another example, the compound is according to paragraph [0089], wherein U^2 is either $-CH_2-$ or absent.

[0091] In another example, the compound is according to paragraph [0090], wherein Y is $-CH_2-$.

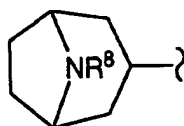
[0092] In another example, the compound is according to paragraph [0091], wherein at least one of R^2 is halogen.

[0093] In another example, the compound is according to paragraph [0091], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0094] In another example, the compound is according to paragraph [0092], wherein at least one of R^{20} is halogen.

[0095] In another example, the compound is according to paragraph [0094], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

[0096] In another example, the compound is according to paragraph [0054], wherein said saturated bridged ring system is according to formula X.



X

[0097] In another example, the compound is according to paragraph [0096], wherein R^8 is methyl or ethyl.

[0098] In another example, the compound is according to paragraph [0097], wherein at least one of R^2 is halogen.

[0099] In another example, the compound is according to paragraph [0097], wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

[0100] In another example, the compound is according to paragraph [0098], wherein at least one of R^{20} is halogen.

[0101] In another example, the compound is according to paragraph [0100], wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

[0102] In another example, the compound is according to paragraph [0029], selected from Table 1:

Table 1

Entry	Name	Structure
1	N-(6-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
2	N-(6-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	
3	N-(6-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-(phenylmethyl)cyclopropane-1,1-dicarboxamide	
4	N-(6-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-phenylcyclopropane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
5	N-[3-fluoro-4-((6-(methyloxy)-7-ylpropyl)oxy)quinolin-4-yl]oxyphenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
6	N-[3-fluoro-4-((6-(methyloxy)-7-ylpropyl)oxy)quinolin-4-yl]oxyphenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
7	N-[3-fluoro-4-((6-(methyloxy)-7-ylpropyl)oxy)quinolin-4-yl]oxyphenyl]-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	
8	N-(6-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-(2-phenylethyl)cyclopropane-1,1-dicarboxamide	
9	N-(6-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
10	N-{4-[(7-chloroquinolin-4-yl)oxy]-3-fluorophenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
11	N-(4-[(7-chloroquinolin-4-yl)oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
12	N-(4-[[6,7-bis(methoxy)quinolin-4-yl]oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
13	N-(4-[[6,7-bis(methoxy)quinazolin-4-yl]oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
14	N-(4-[[6,7-bis(methoxy)quinazolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
15	N-[3-fluoro-4-((6-(methoxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
16	N-[5-chloro-6-[(6-(methyloxy)-7-[[[(1-methylpiperidin-4-yl)methyl]oxy]quinolin-4-yl]oxy]pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
17	N-[5-chloro-6-[(6-(methyloxy)-7-[(piperidin-4-ylmethyl)oxy]quinolin-4-yl]oxy]pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
18	N-[5-chloro-6-[(6-(methyloxy)-7-[(phenylmethyl)oxy]quinolin-4-yl]oxy]pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
19	N-(4-[[7-[[2-(diethylamino)ethyl]oxy]-6-(methyloxy)quinolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
20	N-(4-[[7-[[2-(diethylamino)ethyl]oxy]-6-(methyloxy)quinolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
21	N-{3-fluoro-4-[(6-(methyloxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy)quinazolin-4-yl]oxy}phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
22	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
23	N-(4-fluorophenyl)-N'-[2-methyl-6-[(6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy]pyridin-3-yl]cyclopropane-1,1-dicarboxamide	
24	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
25	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloro-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
26	N-[3-fluoro-4-({7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl}oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
27	N-(4-{[6,7-bis(methyloxy)quinolin-4-yl]oxy}-3,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
28	N-(4-{[6,7-bis(methyloxy)quinolin-4-yl]oxy}-2,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
29	N-[3-fluoro-4-({7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl}oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
30	N-[3-fluoro-4-[(6-(methyloxy)-7-(2-methyl octahydrocyclopenta[c]pyrrol-5-ylmethoxy)quinazolin-4-yl]oxy]phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
31	N-{3-fluoro-4-[(7-(methoxy)-6-(((1-methylpiperidin-4-yl)methyl)oxy)quinazolin-4-yl)oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
32	N-[5-fluoro-2-methyl-4-((6-(methoxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
33	N-(4-[[6,7-bis(methoxy)quinolin-4-yl]oxy]-2,3,5-trifluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
34	N-(4-[[6,7-bis(methoxy)quinolin-4-yl]oxy]-5-fluoro-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
35	N-(4-[[6,7-bis(methoxy)quinolin-4-yl]oxy]-2-chloro-5-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Table 1

Entry	Name	Structure
36	N-(3-fluoro-4-([6-hydroxy-7-(methoxy)quinolin-4-yl]oxy)phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
37	N-(4-fluorophenyl)-N'-[2-methyl-4-([6-(methoxy)-7-[(3-morpholin-4-yl)propyl]oxy]quinolin-4-yl]oxy)phenyl]cyclopropane-1,1-dicarboxamide	

[0103] Another aspect of the invention is a pharmaceutical composition comprising a compound according to any one of paragraphs [0029]-[0102] and a pharmaceutically acceptable carrier.

[0104] Another aspect of the invention is a metabolite of the compound or the pharmaceutical composition according to any one of paragraphs [0029]-[0103].

[0105] Another aspect of the invention is a method of modulating the *in vivo* activity of a kinase, the method comprising administering to a subject an effective amount of the compound or the pharmaceutical composition according to any of paragraphs [0029]-[0103].

[0106] Another aspect of the invention is the method according to paragraph [0105], wherein the kinase is at least one of c-Met, KDR, c-Kit, flt-3, and flt-4.

[0107] Another aspect of the invention is the method according to paragraph [0105], wherein the kinase is c-Met.

[0108] Another aspect of the invention is the method according to paragraph [0107], wherein modulating the *in vivo* activity of the kinase comprises inhibition of said kinase.

[0109] Another aspect of the invention is a method of treating diseases or disorders associated with uncontrolled, abnormal, and/or unwanted cellular activities, the method comprising



administering, to a mammal in need thereof, a therapeutically effective amount of the compound or the pharmaceutical composition as described in any one of paragraphs [0029]-[0103].

[0110] Another aspect of the invention is a method of screening for a modulator of a kinase, said kinase selected from c-Met, KDR, c-Kit, flt-3, and flt-4, the method comprising combining a compound according to any one of paragraphs [0029]-[0102], and at least one candidate agent and determining the effect of the candidate agent on the activity of said kinase.

[0111] Another aspect of the invention is a method of inhibiting proliferative activity in a cell, the method comprising administering an effective amount of a composition comprising a compound according any one of paragraphs [0029]-[0102] to a cell or a plurality of cells.

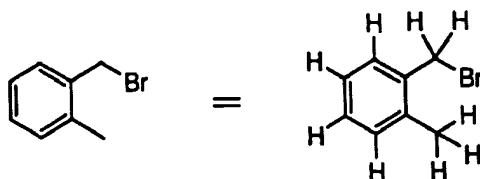
Definitions

[0112] As used in the present specification, the following words and phrases are generally intended to have the meanings as set forth below, except to the extent that the context in which they are used indicates otherwise or they are expressly defined to mean something different.

[0113] The symbol “-” means a single bond, “=” means a double bond, “≡” means a triple bond. The symbol “” refers to a group on a double-bond as occupying either position on the terminus of a double bond to which the symbol is attached; that is, the geometry, *E*- or *Z*-, of the double bond is ambiguous. When a group is depicted removed from its parent formula, the “” symbol will be used at the end of the bond which was theoretically cleaved in order to separate the group from its parent structural formula.

[0114] When chemical structures are depicted or described, unless explicitly stated otherwise, all carbons are assumed to have hydrogen substitution to conform to a valence of four. For example, in the structure on the left-hand side of the schematic below there are nine hydrogens implied. The nine hydrogens are depicted in the right-hand structure. Sometimes a particular atom in a structure is described in textual formula as having a hydrogen or hydrogens as substitution (expressly defined hydrogen), for example, -CH₂CH₂-. It is understood by one of ordinary skill in the art that the aforementioned descriptive techniques

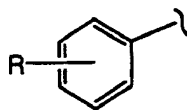
are common in the chemical arts to provide brevity and simplicity to description of otherwise complex structures.



[0115] In this application, some ring structures are depicted generically and will be described textually. For example, in the schematic below, if in the structure on the left, ring A is used to describe a “spirocyclyl,” then if ring A is cyclopropyl, there are at most four hydrogens on ring A (when “R” can also be -H). In another example, as depicted on the right side of the schematic below, if ring B is used to describe a “phenylene” then there can be at most four hydrogens on ring B (assuming depicted cleaved bonds are not C-H bonds).

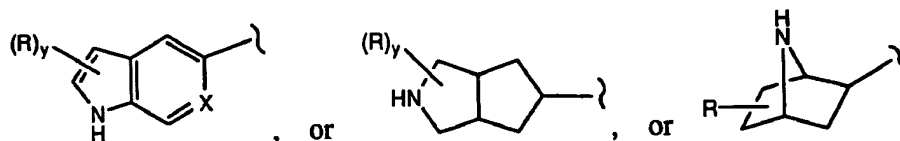


[0116] If a group “R” is depicted as “floating” on a ring system, as for example in the formula:



then, unless otherwise defined, a substituent “R” may reside on any atom of the ring system, assuming replacement of a depicted, implied, or expressly defined hydrogen from one of the ring atoms, so long as a stable structure is formed.

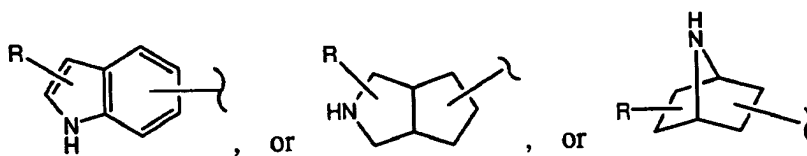
[0117] If a group “R” is depicted as floating on a fused ring system, as for example in the formulae:



then, unless otherwise defined, a substituent “R” may reside on any atom of the fused ring system, assuming replacement of a depicted (for example the -NH- in the formula above), implied (for example as in the formula above, where the hydrogens are not shown but

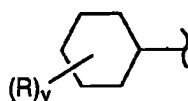
understood to be present), or expressly defined hydrogen (for example where in the formula above, "X" equals =CH-) from one of the ring atoms, so long as a stable structure is formed. In the example depicted, the "R" group may reside on either the 5-membered or the 6-membered ring of the fused ring system. In the formula depicted above, when y is 2 for example, then the two "R's" may reside on any two atoms of the ring system, again assuming each replaces a depicted, implied, or expressly defined hydrogen on the ring.

[0118] When there are more than one such depicted "floating" groups, as for example in the formulae:

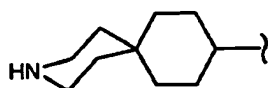


where there are two groups, namely, the "R" and the bond indicating attachment to a parent structure; then, unless otherwise defined, the "floating" groups may reside on any atoms of the ring system, again assuming each replaces a depicted, implied, or expressly defined hydrogen on the ring.

[0119] When a group "R" is depicted as existing on a ring system containing saturated carbons, as for example in the formula:



where, in this example, "y" can be more than one, assuming each replaces a currently depicted, implied, or expressly defined hydrogen on the ring; then, unless otherwise defined, where the resulting structure is stable, two "R's" may reside on the same carbon. A simple example is when R is a methyl group; there can exist a geminal dimethyl on a carbon of the depicted ring (an "annular" carbon). In another example, two R's on the same carbon, including that carbon, may form a ring, thus creating a spirocyclic ring (a "spirocyclyl" group) structure with the depicted ring as for example in the formula:



[0120] "Alkyl" is intended to include linear, branched, or cyclic hydrocarbon structures and combinations thereof, inclusively. For example, "C₈ alkyl" may refer to an *n*-octyl, *iso*-octyl,

cyclohexylethyl, and the like. Lower alkyl refers to alkyl groups of from one to six carbon atoms. Examples of lower alkyl groups include methyl, ethyl, propyl, isopropyl, butyl, *s*-butyl, *t*-butyl, isobutyl, pentyl, hexyl and the like. Higher alkyl refers to alkyl groups containing more than eight carbon atoms. Exemplary alkyl groups are those of C₂₀ or below. Cycloalkyl is a subset of alkyl and includes cyclic hydrocarbon groups of from three to thirteen carbon atoms. Examples of cycloalkyl groups include *c*-propyl, *c*-butyl, *c*-pentyl, norbornyl, adamantyl and the like. In this application, alkyl refers to alkanyl, alkenyl, and alkynyl residues (and combinations thereof); it is intended to include cyclohexylmethyl, vinyl, allyl, isoprenyl, and the like. Thus when an alkyl residue having a specific number of carbons is named, all geometric isomers having that number of carbons are intended to be encompassed; thus, for example, either "butyl" or "C₄ alkyl" is meant to include *n*-butyl, *sec*-butyl, isobutyl, *t*-butyl, isobutenyl and but-2-yne radicals; and for example, "propyl" or "C₃ alkyl" each include *n*-propyl, propenyl, and isopropyl.

[0121] "Alkylene" refers to straight or branched chain divalent radical consisting solely of carbon and hydrogen atoms, containing no unsaturation and having from one to ten carbon atoms, for example, methylene, ethylene, propylene, *n*-butylene and the like. Alkylene is a subset of alkyl, referring to the same residues as alkyl, but having two points of attachment and, specifically, fully saturated. Examples of alkylene include ethylene (-CH₂CH₂-), propylene (-CH₂CH₂CH₂-), dimethylpropylene (-CH₂C(CH₃)₂CH₂-), and cyclohexylpropylene (-CH₂CH₂CH(C₆H₁₃)).

[0122] "Alkylidene" refers to a straight or branched chain unsaturated divalent radical consisting solely of carbon and hydrogen atoms, having from two to ten carbon atoms, for example, ethylidene, propylidene, *n*-butylidene, and the like. Alkylidene is a subset of alkyl, referring to the same residues as alkyl, but having two points of attachment and, specifically, double bond unsaturation. The unsaturation present includes at least one double bond.

[0123] "Alkylidyne" refers to a straight or branched chain unsaturated divalent radical consisting solely of carbon and hydrogen atoms having from two to ten carbon atoms, for example, propylid-2-ynyl, *n*-butylid-1-ynyl, and the like. Alkylidyne is a subset of alkyl, referring to the same residues as alkyl, but having two points of attachment and, specifically, triple bond unsaturation. The unsaturation present includes at least one triple bond.

- [0124] Any of the above radicals, “alkylene,” “alkylidene” and “alkylidyne,” when optionally substituted, may contain alkyl substitution which itself contains unsaturation. For example, 2-(2-phenylethynyl-but-3-enyl)-naphthalene (IUPAC name) contains an *n*-butylid-3-ynyl radical with a vinyl substituent at the 2-position of said radical.
- [0125] “Alkoxy” or “alkoxyl” refers to the group -O-alkyl, for example including from one to eight carbon atoms of a straight, branched, cyclic configuration, unsaturated chains, and combinations thereof attached to the parent structure through an oxygen atom. Examples include methoxy, ethoxy, propoxy, isopropoxy, cyclopropyloxy, cyclohexyloxy and the like. Lower-alkoxy refers to groups containing one to six carbons.
- [0126] “Substituted alkoxy” refers to the group -O-(substituted alkyl), the substitution on the alkyl group generally containing more than only carbon (as defined by alkoxy). One exemplary substituted alkoxy group is “polyalkoxy” or -O-optionally substituted alkylene-optionally substituted alkoxy, and includes groups such as -OCH₂CH₂OCH₃, and glycol ethers such as polyethyleneglycol and -O(CH₂CH₂O)_xCH₃, where *x* is an integer of between about two and about twenty, in another example, between about two and about ten, and in a further example between about two and about five. Another exemplary substituted alkoxy group is hydroxyalkoxy or -OCH₂(CH₂)_yOH, where *y* is for example an integer of between about one and about ten, in another example *y* is an integer of between about one and about four.
- [0127] “Acyl” refers to groups of from one to ten carbon atoms of a straight, branched, cyclic configuration, saturated, unsaturated and aromatic and combinations thereof, attached to the parent structure through a carbonyl functionality. One or more carbons in the acyl residue may be replaced by nitrogen, oxygen or sulfur as long as the point of attachment to the parent remains at the carbonyl. Examples include acetyl, benzoyl, propionyl, isobutyryl, *t*-butoxycarbonyl, benzyloxycarbonyl and the like. Lower-acyl refers to groups containing one to six carbons.
- [0128] “ α -Amino Acids” refer to naturally occurring and commercially available amino acids and optical isomers thereof. Typical natural and commercially available α -amino acids are glycine, alanine, serine, homoserine, threonine, valine, norvaline, leucine, isoleucine, norleucine, aspartic acid, glutamic acid, lysine, ornithine, histidine, arginine, cysteine, homocysteine, methionine, phenylalanine, homophenylalanine, phenylglycine,

ortho-tyrosine, meta-tyrosine, para-tyrosine, tryptophan, glutamine, asparagine, proline and hydroxyproline. A "side chain of an α -amino acid" refers to the radical found on the α -carbon of an α -amino acid as defined above, for example, hydrogen (for glycine), methyl (for alanine), benzyl (for phenylalanine), and the like.

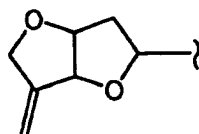
[0129] "Amino" refers to the group -NH_2 . "Substituted amino," refers to the group -N(H)R or -N(R)R where each R is independently selected from the group: optionally substituted alkyl, optionally substituted alkoxy, optionally substituted aryl, optionally substituted heterocyclyl, acyl, carboxy, alkoxycarbonyl, sulfanyl, sulfinyl and sulfonyl, for example, diethylamino, methylsulfonylamino, furanyl-oxy-sulfonamino.

[0130] "Aryl" refers to aromatic six- to fourteen-membered carbocyclic ring, for example, benzene, naphthalene, indane, tetralin, fluorene and the like, univalent radicals. As univalent radicals, the aforementioned ring examples are named, phenyl, naphthyl, indanyl, tetralinyl, and fluorenyl.

[0131] "Arylene" generically refers to any aryl that has at least two groups attached thereto. For a more specific example, "phenylene" refers to a divalent phenyl ring radical. A phenylene, thus may have more than two groups attached, but is defined by a minimum of two non-hydrogen groups attached thereto.

[0132] "Arylalkyl" refers to a residue in which an aryl moiety is attached to a parent structure via one of an alkylene, alkylidene, or alkylidyne radical. Examples include benzyl, phenethyl, phenylvinyl, phenylallyl and the like. Both the aryl, and the corresponding alkylene, alkylidene, or alkylidyne radical portion of an arylalkyl group may be optionally substituted. "Lower arylalkyl" refers to an arylalkyl where the "alkyl" portion of the group has one to six carbons; this can also be referred to as C_{1-6} arylalkyl.

[0133] "Exo-alkenyl" refers to a double bond that emanates from an annular carbon, and is not within the ring system, for example the double bond depicted in the formula below.



[0134] In some examples, as appreciated by one of ordinary skill in the art, two adjacent groups on an aromatic system may be fused together to form a ring structure. The fused ring

structure may contain heteroatoms and may be optionally substituted with one or more groups. It should additionally be noted that saturated carbons of such fused groups (i.e. saturated ring structures) can contain two substitution groups.

- [0135] “Fused-polycyclic” or “fused ring system” refers to a polycyclic ring system that contains bridged or fused rings; that is, where two rings have more than one shared atom in their ring structures. In this application, fused-polycyclics and fused ring systems are not necessarily all aromatic ring systems. Typically, but not necessarily, fused-polycyclics share a vicinal set of atoms, for example naphthalene or 1,2,3,4-tetrahydro-naphthalene. A spiro ring system is not a fused-polycyclic by this definition, but fused polycyclic ring systems of the invention may themselves have spiro rings attached thereto via a single ring atom of the fused-polycyclic.
- [0136] “Halogen” or “halo” refers to fluorine, chlorine, bromine or iodine. “Haloalkyl” and “haloaryl” refer generically to alkyl and aryl radicals that are substituted with one or more halogens, respectively. Thus, “dihaloaryl,” “dihaloalkyl,” “trihaloaryl” etc. refer to aryl and alkyl substituted with a plurality of halogens, but not necessarily a plurality of the same halogen; thus 4-chloro-3-fluorophenyl is within the scope of dihaloaryl.
- [0137] “Heteroarylene” generically refers to any heteroaryl that has at least two groups attached thereto. For a more specific example, “pyridylene” refers to a divalent pyridyl ring radical. A pyridylene, thus may have more than two groups attached, but is defined by a minimum of two non-hydrogen groups attached thereto.
- [0138] “Heteroatom” refers to O, S, N, or P.
- [0139] “Heterocyclyl” refers to a stable three- to fifteen-membered ring radical that consists of carbon atoms and from one to five heteroatoms selected from the group consisting of nitrogen, phosphorus, oxygen and sulfur. For purposes of this invention, the heterocyclyl radical may be a monocyclic, bicyclic or tricyclic ring system, which may include fused or bridged ring systems as well as spirocyclic systems; and the nitrogen, phosphorus, carbon or sulfur atoms in the heterocyclyl radical may be optionally oxidized to various oxidation states. In a specific example, the group $-S(O)_{0-2}$, refers to $-S-$ (sulfide), $-S(O)-$ (sulfoxide), and $-SO_2-$ (sulfone). For convenience, nitrogens, particularly but not exclusively, those defined as annular aromatic nitrogens, are meant to include their corresponding *N*-oxide form, although not explicitly defined as such in a particular example. Thus, for a compound of the invention

having, for example, a pyridyl ring; the corresponding pyridyl-*N*-oxide is meant to be included as another compound of the invention. In addition, annular nitrogen atoms may be optionally quaternized; and the ring radical may be partially or fully saturated or aromatic. Examples of heterocyclyl radicals include, but are not limited to, azetidiny, acridiny, benzodioxoly, benzodioxanyl, benzofuranyl, carbazoyl, cinnoliny, dioxolanyl, indoliziny, naphthyridiny, perhydroazepiny, phenaziny, phenothiaziny, phenoxaziny, phthalaziny, pteridiny, puriny, quinazoliny, quinoxaliny, quinoliny, isoquinoliny, tetrazoyl, tetrahydroisoquinoly, piperidiny, piperaziny, 2-oxopiperaziny, 2-oxopiperidiny, 2-oxopyrrolidiny, 2-oxoazepiny, azepiny, pyrroly, 4-piperidony, pyrrolidiny, pyrazoly, pyrazolidiny, imidazoly, imidazoliny, imidazolidiny, dihydropyridiny, tetrahydropyridiny, pyridiny, pyraziny, pyrimidiny, pyridaziny, oxazoly, oxazoliny, oxazolidiny, triazoly, isoxazoly, isoxazolidiny, morpholiny, thiazoly, thiazoliny, thiazolidiny, isothiazoly, quinuclidiny, isothiazolidiny, indoly, isoindoly, indoliny, isoindoliny, octahydroindoly, octahydroisoindoly, quinoly, isoquinoly, decahydroisoquinoly, benzimidazoly, thiadiazoly, benzopyranyl, benzothiazoly, benzoxazoly, furyl, tetrahydrofuryl, tetrahydropyranyl, thienyl, benzothieliyl, thiamorpholiny, thiamorpholiny sulfoxide, thiamorpholiny sulfone, dioxaphospholanyl, and oxadiazoly.

[0140] "Heteroalicyclic" refers specifically to a non-aromatic heterocyclyl radical. A heteroalicyclic may contain unsaturation, but is not aromatic.

[0141] "Heteroaryl" refers specifically to an aromatic heterocyclyl radical.

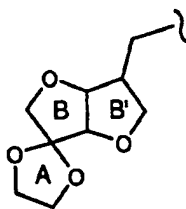
[0142] "Heterocyclylalkyl" refers to a residue in which a heterocyclyl is attached to a parent structure via one of an alkylene, alkylidene, or alkylidyne radical. Examples include (4-methylpiperazin-1-yl) methyl, (morpholin-4-yl) methyl, (pyridine-4-yl) methyl, 2-(oxazolin-2-yl) ethyl, 4-(4-methylpiperazin-1-yl)-2-butenyl, and the like. Both the heterocyclyl, and the corresponding alkylene, alkylidene, or alkylidyne radical portion of a heterocyclylalkyl group may be optionally substituted. "Lower heterocyclylalkyl" refers to a heterocyclylalkyl where the "alkyl" portion of the group has one to six carbons. "Heteroalicycylalkyl" refers specifically to a heterocyclylalkyl where the heterocyclyl portion of the group is non-aromatic; and "heteroarylalkyl" refers specifically to a heterocyclylalkyl where the heterocyclyl portion of the group is aromatic. Such terms may be

described in more than one way, for example, "lower heterocyclalkyl" and "heterocycl C₁₋₆alkyl" are equivalent terms.

[0143] "Optional" or "optionally" means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where said event or circumstance occurs and instances in which it does not. One of ordinary skill in the art would understand that, with respect to any molecule described as containing one or more optional substituents, that only sterically practical and/or synthetically feasible compounds are meant to be included. "Optionally substituted" refers to all subsequent modifiers in a term, for example in the term "optionally substituted arylC₁₋₈ alkyl," optional substitution may occur on both the "C₁₋₈ alkyl" portion and the "aryl" portion of the molecule; and for example, optionally substituted alkyl includes optionally substituted cycloalkyl groups, which in turn are defined as including optionally substituted alkyl groups, potentially *ad infinitum*. A list of exemplary optional substitution are listed below in the definition of "substituted."

[0144] "Saturated bridged ring system" refers to a bicyclic or polycyclic ring system that is not aromatic. Such a system may contain isolated or conjugated unsaturation, but not aromatic or heteroaromatic rings in its core structure (but may have aromatic substitution thereon). For example, hexahydro-furo[3,2-b]furan, 2,3,3a,4,7,7a-hexahydro-1H-indene, 7-aza-bicyclo[2.2.1]heptane, and 1,2,3,4,4a,5,8,8a-octahydro-naphthalene are all included in the class "saturated bridged ring system."

[0145] "Spirocycl" or "spirocyclic ring" refers to a ring originating from a particular annular carbon of another ring. For example, as depicted below, a ring atom of a saturated bridged ring system (rings B and B'), but not a bridgehead atom, can be a shared atom between the saturated bridged ring system and a spirocycl (ring A) attached thereto. A spirocycl can be carbocyclic or heteroalicyclic.



[0146] "Substituted" alkyl, aryl, and heterocycl, refer respectively to alkyl, aryl, and heterocycl, wherein one or more (for example up to about five, in another example, up to about three) hydrogen atoms are replaced by a substituent independently selected from:

optionally substituted alkyl (for example, fluoromethyl), optionally substituted aryl (for example, 4-hydroxyphenyl), optionally substituted arylalkyl (for example, 1-phenyl-ethyl), optionally substituted heterocyclalkyl (for example, 1-pyridin-3-yl-ethyl), optionally substituted heterocycl (for example, 5-chloro-pyridin-3-yl or 1-methyl-piperidin-4-yl), optionally substituted alkoxy, alkylenedioxy (for example methylenedioxy), optionally substituted amino (for example, alkylamino and dialkylamino), optionally substituted amidino, optionally substituted aryloxy (for example, phenoxy), optionally substituted arylalkyloxy (for example, benzyloxy), carboxy ($-\text{CO}_2\text{H}$), carboalkoxy (that is, acyloxy or $-\text{OC}(=\text{O})\text{R}$), carboxyalkyl (that is, esters or $-\text{CO}_2\text{R}$), carboxamido, benzyloxycarbonylamino (CBZ-amino), cyano, acyl, halogen, hydroxy, nitro, sulfanyl, sulfinyl, sulfonyl, thiol, halogen, hydroxy, oxo, carbamyl, acylamino, and sulfonamido.

[0147] "Sulfanyl" refers to the groups: $-\text{S}$ -(optionally substituted alkyl), $-\text{S}$ -(optionally substituted aryl), and $-\text{S}$ -(optionally substituted heterocycl).

[0148] "Sulfinyl" refers to the groups: $-\text{S}(\text{O})-\text{H}$, $-\text{S}(\text{O})$ -(optionally substituted alkyl), $-\text{S}(\text{O})$ -(optionally substituted aryl), and $-\text{S}(\text{O})$ -(optionally substituted heterocycl).

[0149] "Sulfonyl" refers to the groups: $-\text{S}(\text{O}_2)-\text{H}$, $-\text{S}(\text{O}_2)$ -(optionally substituted alkyl), $-\text{S}(\text{O}_2)$ -(optionally substituted aryl), $-\text{S}(\text{O}_2)$ -(optionally substituted heterocycl), $-\text{S}(\text{O}_2)$ -(optionally substituted alkoxy), $-\text{S}(\text{O}_2)$ -(optionally substituted aryloxy), and $-\text{S}(\text{O}_2)$ -(optionally substituted heterocyclloxy).

[0150] "Yield" for each of the reactions described herein is expressed as a percentage of the theoretical yield.

[0151] Some of the compounds of the invention may have imino, amino, oxo or hydroxy substituents off aromatic heterocycl systems. For purposes of this disclosure, it is understood that such imino, amino, oxo or hydroxy substituents may exist in their corresponding tautomeric form, i.e., amino, imino, hydroxy or oxo, respectively.

[0152] Compounds of the invention are named according to systematic application of the nomenclature rules agreed upon by the International Union of Pure and Applied Chemistry (IUPAC), International Union of Biochemistry and Molecular Biology (IUBMB), and the Chemical Abstracts Service (CAS).

- [0153] The compounds of the invention, or their pharmaceutically acceptable salts, may have asymmetric carbon atoms, oxidized sulfur atoms or quaternized nitrogen atoms in their structure.
- [0154] The compounds of the invention and their pharmaceutically acceptable salts may exist as single stereoisomers, racemates, and as mixtures of enantiomers and diastereomers. The compounds may also exist as geometric isomers. All such single stereoisomers, racemates and mixtures thereof, and geometric isomers are intended to be within the scope of this invention.
- [0155] It is assumed that when considering generic descriptions of compounds of the invention for the purpose of constructing a compound, such construction results in the creation of a stable structure. That is, one of ordinary skill in the art would recognize that there can theoretically be some constructs which would not normally be considered as stable compounds (that is, sterically practical and/or synthetically feasible, *supra*).
- [0156] When a particular group with its bonding structure is denoted as being bonded to two partners; that is, a divalent radical, for example, $\text{-OCH}_2\text{-}$, then it is understood that either of the two partners may be bound to the particular group at one end, and the other partner is necessarily bound to the other end of the particular group, unless stated explicitly otherwise. Stated another way, divalent radicals are not to be construed as limited to the depicted orientation, for example " $\text{-OCH}_2\text{-}$ " is meant to mean not only " $\text{-OCH}_2\text{-}$ " as drawn, but also " $\text{-CH}_2\text{O-}$."
- [0157] Methods for the preparation and/or separation and isolation of single stereoisomers from racemic mixtures or non-racemic mixtures of stereoisomers are well known in the art. For example, optically active (R)- and (S)- isomers may be prepared using chiral synthons or chiral reagents, or resolved using conventional techniques. Enantiomers (R- and S-isomers) may be resolved by methods known to one of ordinary skill in the art, for example by: formation of diastereoisomeric salts or complexes which may be separated, for example, by crystallization; via formation of diastereoisomeric derivatives which may be separated, for example, by crystallization, selective reaction of one enantiomer with an enantiomer-specific reagent, for example enzymatic oxidation or reduction, followed by separation of the modified and unmodified enantiomers; or gas-liquid or liquid chromatography in a chiral environment, for example on a chiral support, such as silica with a bound chiral ligand or in the presence of a chiral solvent. It will be appreciated that where a desired enantiomer is

converted into another chemical entity by one of the separation procedures described above, a further step may be required to liberate the desired enantiomeric form. Alternatively, specific enantiomer may be synthesized by asymmetric synthesis using optically active reagents, substrates, catalysts or solvents, or by converting one enantiomer to the other by asymmetric transformation. For a mixture of enantiomers, enriched in a particular enantiomer, the major component enantiomer may be further enriched (with concomitant loss in yield) by recrystallization.

[0158] “Patient” for the purposes of the present invention includes humans and other animals, particularly mammals, and other organisms. Thus the methods are applicable to both human therapy and veterinary applications. In a preferred embodiment the patient is a mammal, and in a most preferred embodiment the patient is human.

[0159] “Kinase-dependent diseases or conditions” refer to pathologic conditions that depend on the activity of one or more protein kinases. Kinases either directly or indirectly participate in the signal transduction pathways of a variety of cellular activities including proliferation, adhesion, migration, differentiation and invasion. Diseases associated with kinase activities include tumor growth, the pathologic neovascularization that supports solid tumor growth, and associated with other diseases where excessive local vascularization is involved such as ocular diseases (diabetic retinopathy, age-related macular degeneration, and the like) and inflammation (psoriasis, rheumatoid arthritis, and the like).

[0160] While not wishing to be bound to theory, phosphatases can also play a role in “kinase-dependent diseases or conditions” as cognates of kinases; that is, kinases phosphorylate and phosphatases dephosphorylate, for example protein substrates. Therefore compounds of the invention, while modulating kinase activity as described herein, may also modulate, either directly or indirectly, phosphatase activity. This additional modulation, if present, may be synergistic (or not) to activity of compounds of the invention toward a related or otherwise interdependent kinase or kinase family. In any case, as stated previously, the compounds of the invention are useful for treating diseases characterized in part by abnormal levels of cell proliferation (i.e. tumor growth), programmed cell death (apoptosis), cell migration and invasion and angiogenesis associated with tumor growth.

[0161] “Therapeutically effective amount” is an amount of a compound of the invention, that when administered to a patient, ameliorates a symptom of the disease. The amount of a

compound of the invention which constitutes a "therapeutically effective amount" will vary depending on the compound, the disease state and its severity, the age of the patient to be treated, and the like. The therapeutically effective amount can be determined routinely by one of ordinary skill in the art having regard to his own knowledge and to this disclosure.

[0162] "Cancer" refers to cellular-proliferative disease states, including but not limited to: Cardiac: sarcoma (angiosarcoma, fibrosarcoma, rhabdomyosarcoma, liposarcoma), myxoma, rhabdomyoma, fibroma, lipoma and teratoma; Lung: bronchogenic carcinoma (squamous cell, undifferentiated small cell, undifferentiated large cell, adenocarcinoma), alveolar (bronchiolar) carcinoma, bronchial adenoma, sarcoma, lymphoma, chondromatous hamartoma, mesothelioma; Gastrointestinal: esophagus (squamous cell carcinoma, adenocarcinoma, leiomyosarcoma, lymphoma), stomach (carcinoma, lymphoma, leiomyosarcoma), pancreas (ductal adenocarcinoma, insulinoma, glucagonoma, gastrinoma, carcinoid tumors, vipoma), small bowel (adenocarcinoma, lymphoma, carcinoid tumors, Kaposi's sarcoma, leiomyoma, hemangioma, lipoma, neurofibroma, fibroma), large bowel (adenocarcinoma, tubular adenoma, villous adenoma, hamartoma, leiomyoma); Genitourinary tract: kidney (adenocarcinoma, Wilm's tumor [nephroblastoma], lymphoma, leukemia), bladder and urethra (squamous cell carcinoma, transitional cell carcinoma, adenocarcinoma), prostate (adenocarcinoma, sarcoma), testis (seminoma, teratoma, embryonal carcinoma, teratocarcinoma, choriocarcinoma, sarcoma, interstitial cell carcinoma, fibroma, fibroadenoma, adenomatoid tumors, lipoma); Liver: hepatoma (hepatocellular carcinoma), cholangiocarcinoma, hepatoblastoma, angiosarcoma, hepatocellular adenoma, hemangioma; Bone: osteogenic sarcoma (osteosarcoma), fibrosarcoma, malignant fibrous histiocytoma, chondrosarcoma, Ewing's sarcoma, malignant lymphoma (reticulum cell sarcoma), multiple myeloma, malignant giant cell tumor chordoma, osteochondroma (osteochondrogenous exostoses), benign chondroma, chondroblastoma, chondromyxofibroma, osteoid osteoma and giant cell tumors; Nervous system: skull (osteoma, hemangioma, granuloma, xanthoma, osteitis deformans), meninges (meningioma, meningiosarcoma, gliomatosis), brain (astrocytoma, medulloblastoma, glioma, ependymoma, germinoma [pinealoma], glioblastoma multiform, oligodendroglioma, schwannoma, retinoblastoma, congenital tumors), spinal cord neurofibroma, meningioma, glioma, sarcoma); Gynecological: uterus (endometrial carcinoma), cervix (cervical carcinoma, pre-tumor cervical dysplasia), ovaries (ovarian carcinoma [serous cystadenocarcinoma, mucinous cystadenocarcinoma, unclassified

carcinoma], granulosa-thecal cell tumors, SertoliLeydig cell tumors, dysgerminoma, malignant teratoma), vulva (squamous cell carcinoma, intraepithelial carcinoma, adenocarcinoma, fibrosarcoma, melanoma), vagina (clear cell carcinoma, squamous cell carcinoma, botryoid sarcoma (embryonal rhabdomyosarcoma), fallopian tubes (carcinoma); Hematologic: blood (myeloid leukemia [acute and chronic], acute lymphoblastic leukemia, chronic lymphocytic leukemia, myeloproliferative diseases, multiple myeloma, myelodysplastic syndrome), Hodgkin's disease, non-Hodgkin's lymphoma [malignant lymphoma]; Skin: malignant melanoma, basal cell carcinoma, squamous cell carcinoma, Kaposi's sarcoma, moles dysplastic nevi, lipoma, angioma, dermatofibroma, keloids, psoriasis; and Adrenal glands: neuroblastoma. Thus, the term "cancerous cell" as provided herein, includes a cell afflicted by any one of the above-identified conditions.

[0163] "Pharmaceutically acceptable acid addition salt" refers to those salts that retain the biological effectiveness of the free bases and that are not biologically or otherwise undesirable, formed with inorganic acids such as hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid, and the like, as well as organic acids such as acetic acid, trifluoroacetic acid, propionic acid, glycolic acid, pyruvic acid, oxalic acid, maleic acid, malonic acid, succinic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, p-toluenesulfonic acid, salicylic acid and the like.

[0164] "Pharmaceutically acceptable base addition salts" include those derived from inorganic bases such as sodium, potassium, lithium, ammonium, calcium, magnesium, iron, zinc, copper, manganese, aluminum salts and the like. Exemplary salts are the ammonium, potassium, sodium, calcium, and magnesium salts. Salts derived from pharmaceutically acceptable organic non-toxic bases include, but are not limited to, salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as isopropylamine, trimethylamine, diethylamine, triethylamine, tripropylamine, ethanolamine, 2-dimethylaminoethanol, 2-diethylaminoethanol, dicyclohexylamine, lysine, arginine, histidine, caffeine, procaine, hydrabamine, choline, betaine, ethylenediamine, glucosamine, methylglucamine, theobromine, purines, piperazine, piperidine, N-ethylpiperidine, polyamine resins, and the like. Exemplary organic bases are isopropylamine, diethylamine, ethanolamine, trimethylamine, dicyclohexylamine, choline, and caffeine. (See, for example, S. M. Berge, et

al., "Pharmaceutical Salts," J. Pharm. Sci., 1977;66:1-19 which is incorporated herein by reference.)

[0165] "Prodrug" refers to compounds that are transformed (typically rapidly) *in vivo* to yield the parent compound of the above formulae, for example, by hydrolysis in blood. Common examples include, but are not limited to, ester and amide forms of a compound having an active form bearing a carboxylic acid moiety. Examples of pharmaceutically acceptable esters of the compounds of this invention include, but are not limited to, alkyl esters (for example with between about one and about six carbons) wherein the alkyl group is a straight or branched chain. Acceptable esters also include cycloalkyl esters and arylalkyl esters such as, but not limited to benzyl. Examples of pharmaceutically acceptable amides of the compounds of this invention include, but are not limited to, primary amides, and secondary and tertiary alkyl amides (for example with between about one and about six carbons). Amides and esters of the compounds of the present invention may be prepared according to conventional methods. A thorough discussion of prodrugs is provided in T. Higuchi and V. Stella, "Pro-drugs as Novel Delivery Systems," Vol 14 of the A.C.S. Symposium Series, and in Bioreversible Carriers in Drug Design, ed. Edward B. Roche, American Pharmaceutical Association and Pergamon Press, 1987, both of which are incorporated herein by reference for all purposes.

[0166] "Metabolite" refers to the break-down or end product of a compound or its salt produced by metabolism or biotransformation in the animal or human body; for example, biotransformation to a more polar molecule such as by oxidation, reduction, or hydrolysis, or to a conjugate (see Goodman and Gilman, "The Pharmacological Basis of Therapeutics" 8.sup.th Ed., Pergamon Press, Gilman et al. (eds), 1990 for a discussion of biotransformation). As used herein, the metabolite of a compound of the invention or its salt may be the biologically active form of the compound in the body. In one example, a prodrug may be used such that the biologically active form, a metabolite, is released *in vivo*. In another example, a biologically active metabolite is discovered serendipitously, that is, no prodrug design *per se* was undertaken. An assay for activity of a metabolite of a compound of the present invention is known to one of skill in the art in light of the present disclosure.

[0167] In addition, the compounds of the present invention can exist in unsolvated as well as solvated forms with pharmaceutically acceptable solvents such as water, ethanol, and the like.

In general, the solvated forms are considered equivalent to the unsolvated forms for the purposes of the present invention.

[0168] In addition, it is intended that the present invention cover compounds made either using standard organic synthetic techniques, including combinatorial chemistry or by biological methods, such as bacterial digestion, metabolism, enzymatic conversion, and the like.

[0169] "Treating" or "treatment" as used herein covers the treatment of a disease-state in a human, which disease-state is characterized by abnormal cellular proliferation, and invasion and includes at least one of: (i) preventing the disease-state from occurring in a human, in particular, when such human is predisposed to the disease-state but has not yet been diagnosed as having it; (ii) inhibiting the disease-state, i.e., arresting its development; and (iii) relieving the disease-state, i.e., causing regression of the disease-state. As is known in the art, adjustments for systemic versus localized delivery, age, body weight, general health, sex, diet, time of administration, drug interaction and the severity of the condition may be necessary, and will be ascertainable with routine experimentation by one of ordinary skill in the art.

[0170] One of ordinary skill in the art would understand that certain crystallized, protein-ligand complexes, in particular c-Met, c-Kit, KDR, flt-3, or flt-4-ligand complexes, and their corresponding x-ray structure coordinates can be used to reveal new structural information useful for understanding the biological activity of kinases as described herein. As well, the key structural features of the aforementioned proteins, particularly, the shape of the ligand binding site, are useful in methods for designing or identifying selective modulators of kinases and in solving the structures of other proteins with similar features. Such protein-ligand complexes, having compounds of the invention as their ligand component, are an aspect of the invention.

[0171] As well, one of ordinary skill in the art would appreciate that such suitable x-ray quality crystals can be used as part of a method of identifying a candidate agent capable of binding to and modulating the activity of kinases. Such methods may be characterized by the following aspects: a) introducing into a suitable computer program, information defining a ligand binding domain of a kinase in a conformation (e.g. as defined by x-ray structure coordinates obtained from suitable x-ray quality crystals as described above) wherein the computer program creates a model of the three dimensional structures of the ligand binding

domain, b) introducing a model of the three dimensional structure of a candidate agent in the computer program, c) superimposing the model of the candidate agent on the model of the ligand binding domain, and d) assessing whether the candidate agent model fits spatially into the ligand binding domain. Aspects a-d are not necessarily carried out in the aforementioned order. Such methods may further entail: performing rational drug design with the model of the three-dimensional structure, and selecting a potential candidate agent in conjunction with computer modeling.

[0172] Additionally, one skilled in the art would appreciate that such methods may further entail: employing a candidate agent, so-determined to fit spatially into the ligand binding domain, in a biological activity assay for kinase modulation, and determining whether said candidate agent modulates kinase activity in the assay. Such methods may also include administering the candidate agent, determined to modulate kinase activity, to a mammal suffering from a condition treatable by kinase modulation, such as those described above.

[0173] Also, one skilled in the art would appreciate that compounds of the invention can be used in a method of evaluating the ability of a test agent to associate with a molecule or molecular complex comprising a ligand binding domain of a kinase. Such a method may be characterized by the following aspects: a) creating a computer model of a kinase binding pocket using structure coordinates obtained from suitable x-ray quality crystals of the kinase, b) employing computational algorithms to perform a fitting operation between the test agent and the computer model of the binding pocket, and c) analyzing the results of the fitting operation to quantify the association between the test agent and the computer model of the binding pocket.

General Administration

[0174] Administration of the compounds of the invention, or their pharmaceutically acceptable salts, in pure form or in an appropriate pharmaceutical composition, can be carried out via any of the accepted modes of administration or agents for serving similar utilities. Thus, administration can be, for example, orally, nasally, parenterally (intravenous, intramuscular, or subcutaneous), topically, transdermally, intravaginally, intravesically, intracisternally, or rectally, in the form of solid, semi-solid, lyophilized powder, or liquid dosage forms, such as for example, tablets, suppositories, pills, soft elastic and hard gelatin

capsules, powders, solutions, suspensions, or aerosols, or the like, preferably in unit dosage forms suitable for simple administration of precise dosages.

[0175] The compositions will include a conventional pharmaceutical carrier or excipient and a compound of the invention as the/an active agent, and, in addition, may include other medicinal agents, pharmaceutical agents, carriers, adjuvants, etc. Compositions of the invention may be used in combination with anticancer or other agents that are generally administered to a patient being treated for cancer. Adjuvants include preserving, wetting, suspending, sweetening, flavoring, perfuming, emulsifying, and dispensing agents. Prevention of the action of microorganisms can be ensured by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, and the like. It may also be desirable to include isotonic agents, for example sugars, sodium chloride, and the like. Prolonged absorption of the injectable pharmaceutical form can be brought about by the use of agents delaying absorption, for example, aluminum monostearate and gelatin.

[0176] If desired, a pharmaceutical composition of the invention may also contain minor amounts of auxiliary substances such as wetting or emulsifying agents, pH buffering agents, antioxidants, and the like, such as, for example, citric acid, sorbitan monolaurate, triethanolamine oleate, butylated hydroxytoluene, etc.

[0177] Compositions suitable for parenteral injection may comprise physiologically acceptable sterile aqueous or nonaqueous solutions, dispersions, suspensions or emulsions, and sterile powders for reconstitution into sterile injectable solutions or dispersions. Examples of suitable aqueous and nonaqueous carriers, diluents, solvents or vehicles include water, ethanol, polyols (propyleneglycol, polyethyleneglycol, glycerol, and the like), suitable mixtures thereof, vegetable oils (such as olive oil) and injectable organic esters such as ethyl oleate. Proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersions and by the use of surfactants.

[0178] One preferable route of administration is oral, using a convenient daily dosage regimen that can be adjusted according to the degree of severity of the disease-state to be treated.

[0179] Solid dosage forms for oral administration include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the active compound is admixed with at least one

inert customary excipient (or carrier) such as sodium citrate or dicalcium phosphate or (a) fillers or extenders, as for example, starches, lactose, sucrose, glucose, mannitol, and silicic acid, (b) binders, as for example, cellulose derivatives, starch, alginates, gelatin, polyvinylpyrrolidone, sucrose, and gum acacia, (c) humectants, as for example, glycerol, (d) disintegrating agents, as for example, agar-agar, calcium carbonate, potato or tapioca starch, alginic acid, croscarmellose sodium, complex silicates, and sodium carbonate, (e) solution retarders, as for example paraffin, (f) absorption accelerators, as for example, quaternary ammonium compounds, (g) wetting agents, as for example, cetyl alcohol, and glycerol monostearate, magnesium stearate and the like (h) adsorbents, as for example, kaolin and bentonite, and (i) lubricants, as for example, talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate, or mixtures thereof. In the case of capsules, tablets, and pills, the dosage forms may also comprise buffering agents.

[0180] Solid dosage forms as described above can be prepared with coatings and shells, such as enteric coatings and others well known in the art. They may contain pacifying agents, and can also be of such composition that they release the active compound or compounds in a certain part of the intestinal tract in a delayed manner. Examples of embedded compositions that can be used are polymeric substances and waxes. The active compounds can also be in microencapsulated form, if appropriate, with one or more of the above-mentioned excipients.

[0181] Liquid dosage forms for oral administration include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs. Such dosage forms are prepared, for example, by dissolving, dispersing, etc., a compound(s) of the invention, or a pharmaceutically acceptable salt thereof, and optional pharmaceutical adjuvants in a carrier, such as, for example, water, saline, aqueous dextrose, glycerol, ethanol and the like; solubilizing agents and emulsifiers, as for example, ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propyleneglycol, 1,3-butyleneglycol, dimethylformamide; oils, in particular, cottonseed oil, groundnut oil, corn germ oil, olive oil, castor oil and sesame oil, glycerol, tetrahydrofurfuryl alcohol, polyethyleneglycols and fatty acid esters of sorbitan; or mixtures of these substances, and the like, to thereby form a solution or suspension.

[0182] Suspensions, in addition to the active compounds, may contain suspending agents, as for example, ethoxylated isostearyl alcohols, polyoxyethylene sorbitol and sorbitan esters,

microcrystalline cellulose, aluminum metahydroxide, bentonite, agar-agar and tragacanth, or mixtures of these substances, and the like.

[0183] Compositions for rectal administrations are, for example, suppositories that can be prepared by mixing the compounds of the present invention with for example suitable non-irritating excipients or carriers such as cocoa butter, polyethyleneglycol or a suppository wax, which are solid at ordinary temperatures but liquid at body temperature and therefore, melt while in a suitable body cavity and release the active component therein.

[0184] Dosage forms for topical administration of a compound of this invention include ointments, powders, sprays, and inhalants. The active component is admixed under sterile conditions with a physiologically acceptable carrier and any preservatives, buffers, or propellants as may be required. Ophthalmic formulations, eye ointments, powders, and solutions are also contemplated as being within the scope of this invention.

[0185] Generally, depending on the intended mode of administration, the pharmaceutically acceptable compositions will contain about 1% to about 99% by weight of a compound(s) of the invention, or a pharmaceutically acceptable salt thereof, and 99% to 1% by weight of a suitable pharmaceutical excipient. In one example, the composition will be between about 5% and about 75% by weight of a compound(s) of the invention, or a pharmaceutically acceptable salt thereof, with the rest being suitable pharmaceutical excipients.

[0186] Actual methods of preparing such dosage forms are known, or will be apparent, to those skilled in this art; for example, see Remington's Pharmaceutical Sciences, 18th Ed., (Mack Publishing Company, Easton, Pa., 1990). The composition to be administered will, in any event, contain a therapeutically effective amount of a compound of the invention, or a pharmaceutically acceptable salt thereof, for treatment of a disease-state in accordance with the teachings of this invention.

[0187] The compounds of the invention, or their pharmaceutically acceptable salts, are administered in a therapeutically effective amount which will vary depending upon a variety of factors including the activity of the specific compound employed, the metabolic stability and length of action of the compound, the age, body weight, general health, sex, diet, mode and time of administration, rate of excretion, drug combination, the severity of the particular disease-states, and the host undergoing therapy. The compounds of the present invention can be administered to a patient at dosage levels in the range of about 0.1 to about 1,000 mg per

day. For a normal human adult having a body weight of about 70 kilograms, a dosage in the range of about 0.01 to about 100 mg per kilogram of body weight per day is an example. The specific dosage used, however, can vary. For example, the dosage can depend on a number of factors including the requirements of the patient, the severity of the condition being treated, and the pharmacological activity of the compound being used. The determination of optimum dosages for a particular patient is well known to one of ordinary skill in the art.

Utility of compounds of the invention as screening agents

[0188] To employ the compounds of the invention in a method of screening for candidate agents that bind to, for example c-Met, KDR, c-Kit, flt-3, or flt-4, the protein is bound to a support, and a compound of the invention is added to the assay. Alternatively, the compound of the invention is bound to the support and the protein is added. Classes of candidate agents among which novel binding agents may be sought include specific antibodies, non-natural binding agents identified in screens of chemical libraries, peptide analogs, etc. Of particular interest are screening assays for candidate agents that have a low toxicity for human cells. A wide variety of assays may be used for this purpose, including labeled in vitro protein-protein binding assays, electrophoretic mobility shift assays, immunoassays for protein binding, functional assays (phosphorylation assays, etc.) and the like.

[0189] The determination of the binding of the candidate agent to, for example, c-Met, KDR, c-Kit, flt-3, or flt-4 protein may be done in a number of ways. In one example, the candidate agent (the compound of the invention) is labeled, for example, with a fluorescent or radioactive moiety and binding determined directly. For example, this may be done by attaching all or a portion of the c-Met, KDR, c-Kit, flt-3, or flt-4 protein to a solid support, adding a labeled agent (for example a compound of the invention in which at least one atom has been replaced by a detectable isotope), washing off excess reagent, and determining whether the amount of the label is that present on the solid support. Various blocking and washing steps may be utilized as is known in the art.

[0190] By "labeled" herein is meant that the compound is either directly or indirectly labeled with a label which provides a detectable signal, e.g., radioisotope, fluorescent tag, enzyme, antibodies, particles such as magnetic particles, chemiluminescent tag, or specific binding molecules, etc. Specific binding molecules include pairs, such as biotin and streptavidin,

digoxin and antidigoxin etc. For the specific binding members, the complementary member would normally be labeled with a molecule which provides for detection, in accordance with known procedures, as outlined above. The label can directly or indirectly provide a detectable signal.

[0191] In some embodiments, only one of the components is labeled. For example, c-Met, KDR, c-Kit, flt-3, or flt-4 protein may be labeled at tyrosine positions using ^{125}I , or with fluorophores. Alternatively, more than one component may be labeled with different labels; using ^{125}I for the proteins, for example, and a fluorophor for the candidate agents.

[0192] The compounds of the invention may also be used as competitors to screen for additional drug candidates. "Candidate bioactive agent" or "drug candidate" or grammatical equivalents as used herein describe any molecule, e.g., protein, oligopeptide, small organic molecule, polysaccharide, polynucleotide, etc., to be tested for bioactivity. They may be capable of directly or indirectly altering the cellular proliferation phenotype or the expression of a cellular proliferation sequence, including both nucleic acid sequences and protein sequences. In other cases, alteration of cellular proliferation protein binding and/or activity is screened. In the case where protein binding or activity is screened, some embodiments exclude molecules already known to bind to that particular protein. Exemplary embodiments of assays described herein include candidate agents, which do not bind the target protein in its endogenous native state, termed herein as "exogenous" agents. In one example, exogenous agents further exclude antibodies to c-Met, KDR, c-Kit, flt-3, or flt-4.

[0193] Candidate agents can encompass numerous chemical classes, though typically they are organic molecules having a molecular weight of more than about 100 daltons and less than about 2,500 daltons. Candidate agents comprise functional groups necessary for structural interaction with proteins, particularly hydrogen bonding and lipophilic binding, and typically include at least an amine, carbonyl, hydroxyl, ether, or carboxyl group, for example at least two of the functional chemical groups. The candidate agents often comprise cyclical carbon or heterocyclyl structures and/or aromatic or polyaromatic structures substituted with one or more of the above functional groups. Candidate agents are also found among biomolecules including peptides, saccharides, fatty acids, steroids, purines, pyrimidines, derivatives, structural analogs, or combinations thereof.

- [0194] Candidate agents are obtained from a wide variety of sources including libraries of synthetic or natural compounds. For example, numerous means are available for random and directed synthesis of a wide variety of organic compounds and biomolecules, including expression of randomized oligonucleotides. Alternatively, libraries of natural compounds in the form of bacterial, fungal, plant and animal extracts are available or readily produced. Additionally, natural or synthetically produced libraries and compounds are readily modified through conventional chemical, physical and biochemical means. Known pharmacological agents may be subjected to directed or random chemical modifications, such as acylation, alkylation, esterification, amidification to produce structural analogs.
- [0195] In one example, the binding of the candidate agent is determined through the use of competitive binding assays. In this example, the competitor is a binding moiety known to bind to c-Met, KDR, c-Kit, flt-3, or flt-4, such as an antibody, peptide, binding partner, ligand, etc. Under certain circumstances, there may be competitive binding as between the candidate agent and the binding moiety, with the binding moiety displacing the candidate agent.
- [0196] In some embodiments, the candidate agent is labeled. Either the candidate agent, or the competitor, or both, is added first to for example c-Met, KDR, c-Kit, flt-3, or flt-4 for a time sufficient to allow binding, if present. Incubations may be performed at any temperature that facilitates optimal activity, typically between 4°C and 40°C
- [0197] Incubation periods are selected for optimum activity, but may also be optimized to facilitate rapid high throughput screening. Typically between 0.1 and 1 hour will be sufficient. Excess reagent is generally removed or washed away. The second component is then added, and the presence or absence of the labeled component is followed, to indicate binding.
- [0198] In one example, the competitor is added first, followed by the candidate agent. Displacement of the competitor is an indication the candidate agent is binding to c-Met, KDR, c-Kit, flt-3, or flt-4 and thus is capable of binding to, and potentially modulating, the activity of the c-Met, KDR, c-Kit, flt-3, or flt-4. In this embodiment, either component can be labeled. Thus, for example, if the competitor is labeled, the presence of label in the wash solution indicates displacement by the agent. Alternatively, if the candidate agent is labeled, the presence of the label on the support indicates displacement.

- [0199] In an alternative embodiment, the candidate agent is added first, with incubation and washing, followed by the competitor. The absence of binding by the competitor may indicate the candidate agent is bound to c-Met, KDR, c-Kit, flt-3, or flt-4 with a higher affinity. Thus, if the candidate agent is labeled, the presence of the label on the support, coupled with a lack of competitor binding, may indicate the candidate agent is capable of binding to c-Met, KDR, c-Kit, flt-3, or flt-4.
- [0200] It may be of value to identify the binding site of c-Met, KDR, c-Kit, flt-3, or flt-4. This can be done in a variety of ways. In one embodiment, once c-Met, KDR, c-Kit, flt-3, or flt-4 has been identified as binding to the candidate agent, the c-Met, KDR, c-Kit, flt-3, or flt-4 is fragmented or modified and the assays repeated to identify the necessary components for binding.
- [0201] Modulation is tested by screening for candidate agents capable of modulating the activity of c-Met, KDR, c-Kit, flt-3, or flt-4 comprising the steps of combining a candidate agent with c-Met, KDR, c-Kit, flt-3, or flt-4, as above, and determining an alteration in the biological activity of the c-Met, KDR, c-Kit, flt-3, or flt-4. Thus, in this embodiment, the candidate agent should both bind to (although this may not be necessary), and alter its biological or biochemical activity as defined herein. The methods include both *in vitro* screening methods and *in vivo* screening of cells for alterations in cell viability, morphology, and the like.
- [0202] Alternatively, differential screening may be used to identify drug candidates that bind to native c-Met, KDR, c-Kit, flt-3, or flt-4, but cannot bind to modified c-Met, KDR, c-Kit, flt-3, or flt-4.
- [0203] Positive controls and negative controls may be used in the assays. For example, all control and test samples are performed in at least triplicate to obtain statistically significant results. Incubation of samples is for a time sufficient for the binding of the agent to the protein. Following incubation, samples are washed free of non-specifically bound material and the amount of bound, generally labeled agent determined. For example, where a radiolabel is employed, the samples may be counted in a scintillation counter to determine the amount of bound compound.
- [0204] A variety of other reagents may be included in the screening assays. These include reagents like salts, neutral proteins, e.g., albumin, detergents, etc which may be used to

facilitate optimal protein-protein binding and/or reduce non-specific or background interactions. Also reagents that otherwise improve the efficiency of the assay, such as protease inhibitors, nuclease inhibitors, anti-microbial agents, etc., may be used. The mixture of components may be added in any order that provides for the requisite binding.

[0205] Abbreviations and their Definitions

The following abbreviations and terms have the indicated meanings throughout:

Abbreviation	Meaning
Ac	acetyl
ATP	adenosine triphosphate
BNB	4-bromomethyl-3-nitrobenzoic acid
Boc	t-butyloxy carbonyl
br	broad
Bu	butyl
°C	degrees Celsius
c-	cyclo
CBZ	CarboBenZoxy = benzyloxycarbonyl
d	doublet
dd	doublet of doublet
dt	doublet of triplet
DBU	Diazabicyclo[5.4.0]undec-7-ene
DCM	dichloromethane = methylene chloride = CH_2Cl_2
DCE	dichloroethylene
DEAD	diethyl azodicarboxylate
DIC	diisopropylcarbodiimide
DIEA	N,N-diisopropylethyl amine
DMAP	4-N,N-dimethylaminopyridine
DMF	N,N-dimethylformamide
DMSO	dimethyl sulfoxide
DVB	1,4-divinylbenzene

Abbreviation	Meaning
EEDQ	2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline
EI	Electron Impact ionization
Et	ethyl
Fmoc	9-fluorenylmethoxycarbonyl
g	gram(s)
GC	gas chromatography
h or hr	hour(s)
HATU	0-(7-Azabenzotriazol-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate
HMDS	hexamethyldisilazane
HOAc	acetic acid
HOBt	hydroxybenzotriazole
HPLC	high pressure liquid chromatography
L	liter(s)
M	molar or molarity
m	multiplet
Me	methyl
mesyl	methanesulfonyl
mg	milligram(s)
MHz	megahertz (frequency)
Min	minute(s)
mL	milliliter(s)
mM	millimolar
mmol	millimole(s)
mol	mole(s)
MS	mass spectral analysis
MTBE	methyl t-butyl ether
N	normal or normality
NBS	N-bromosuccinimide
NCS	N-chlorosuccinimide

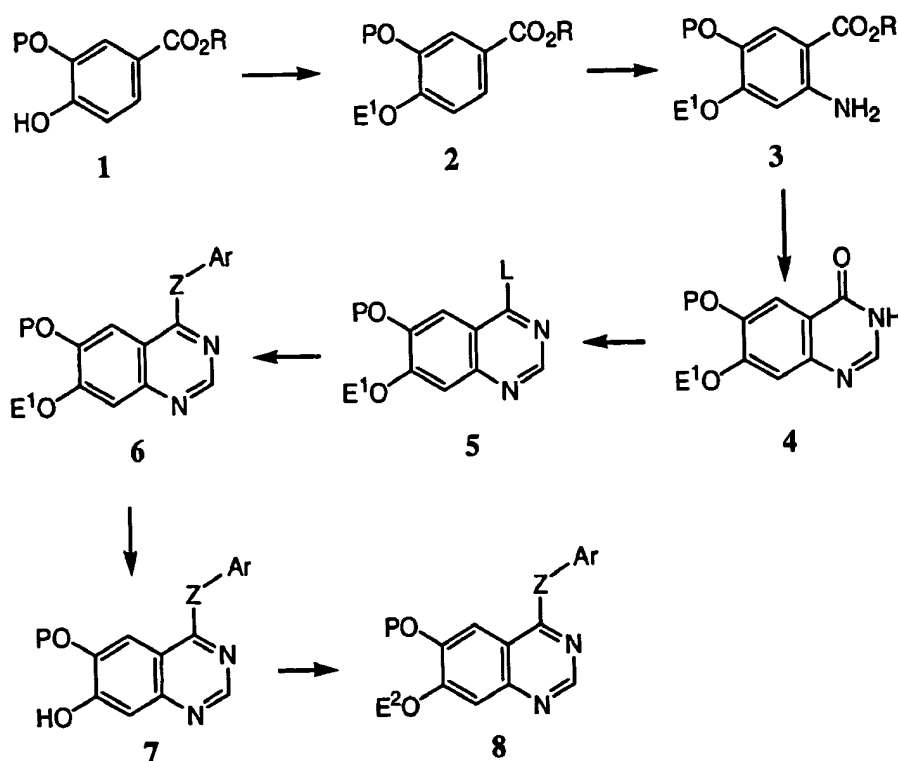
Abbreviation	Meaning
nM	nanomolar
NMO	N-methylmorpholine oxide
NMR	nuclear magnetic resonance spectroscopy
PEG	polyethylene glycol
pEY	poly-glutamine, tyrosine
Ph	phenyl
PhOH	phenol
PfP	pentafluorophenol
PfPy	pentafluoropyridine
PPTS	Pyridinium p-toluenesulfonate
Py	pyridine
PyBroP	bromo-tris-pyrrolidino-phosphonium hexafluorophosphate
q	quartet
RT	Room temperature
Sat'd	saturated
s	singlet
s-	secondary
t-	tertiary
t or tr	triplet
TBDMS	t-butyltrimethylsilyl
TES	triethylsilane
TFA	trifluoroacetic acid
THF	tetrahydrofuran
TMOF	trimethyl orthoformate
TMS	trimethylsilyl
tosyl	p-toluenesulfonyl
Trt	triphenylmethyl
uL	microliter(s)
uM	Micromole(s) or micromolar

Synthesis of Compounds

[0206] Schemes 1 and 2 depict general synthetic routes for compounds of the invention and are not intended to be limiting. More specifically, Scheme 1 depicts synthesis of quinazoline compounds, and Scheme 2 depicts synthesis of quinoline compounds. Specific examples are described subsequently to these general synthetic descriptions so as to allow one of ordinary skill in the art to make and use either quinazolines or quinolines of the invention.

[0207] Referring to Scheme 1, a benzoic ester **1** for example, where R is typically but not necessarily a methyl radical and P is typically but not necessarily an alkyl group, is O-alkylated at the oxygen *para* to the carboxylate group with an electrophile to afford a substituted derivative **2**. P is typically a lower alkyl group, but may be a protecting group that is removed later in a synthesis. When P is a lower alkyl group it may possess functionality initially, or be derivitized to contain such functionality at various stages of the synthesis. The

Scheme 1



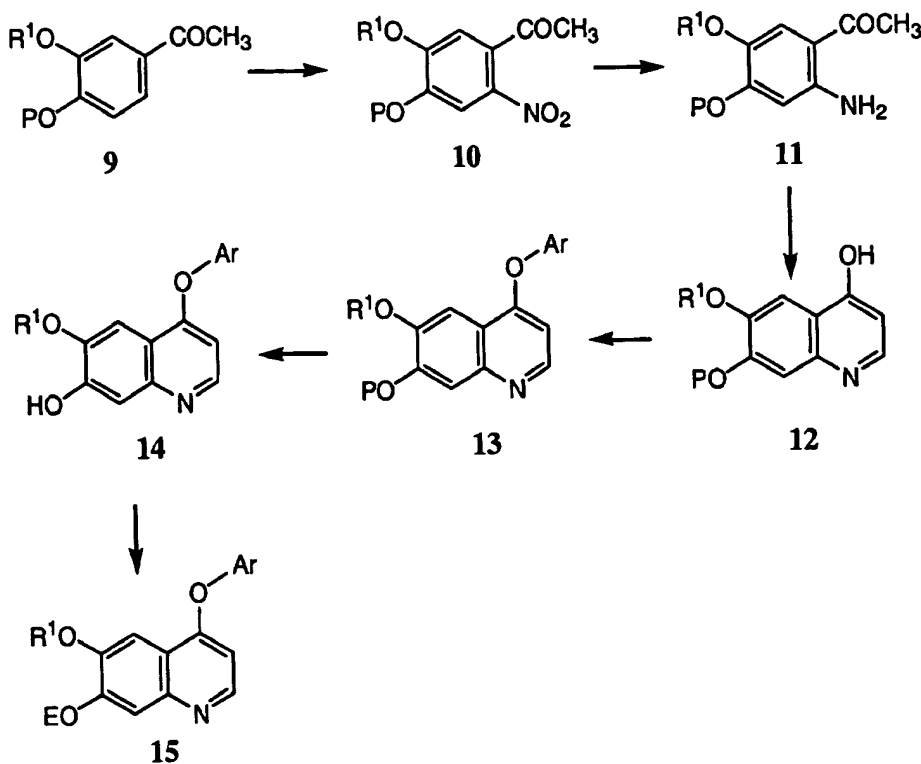
group, E¹, may represent either a protecting group, e.g. benzyl, or a group that either has moieties present in compounds of the invention or possesses functionality that serve as precursors to such groups. Aromatic ring nitration, and reduction of the corresponding nitro group, are carried out in a regio- and chemoselective manner by methods well known in the

art to give anthranilate derivative 3. Formation of quinazolin-4-one 4 is carried out by methods well known in the art, for example by heating 3 in formamide solution in the presence of ammonium formate, or for example by heating 3 with formamidine hydrochloride. Introduction of 4-position functionality is carried out by methods known in the art. For example, quinazolin-4-one 4 is converted to an intermediate quinazoline 5, where "L" represents a leaving group, e.g. chlorine (via dehydration/chlorination of 4 to give 5). Quinazoline 5 is then converted to 6 by reaction with a range of nucleophiles, e.g. amines, alcohols, and thiols. After formation of 6, group "Z" is either left "as is" or converted at some subsequent stage to a derivative thereof. For example when Z is -NH-, then the hydrogen on the nitrogen may optionally be replaced with an alkyl group, or when Z is sulfur, then that sulfur atom may be oxidized to, for example, a sulfone. Structure 6 may represent compounds of the invention or, for example when E¹ serves as a protecting group, E¹ may be removed to provide phenol 7. Introduction of a group E² is carried out by methods well established in the art; for example alkylation with an appropriately derivatized alkyl halide (or mesylate or the like) to give 8 which also represents compounds of the invention.

[0208] Scheme 2 shows a general route used to make exemplary quinolines of the invention. For example, compound 9 contains an alkyl group, R¹, a protecting group, P. The arrangement of the protected and alkylated phenolic oxygens may vary from the pattern depicted in compound 9. Compound 9 is nitrated to provide compound 10. The nitro group of compound 10 is reduced to give aniline 11. Compound 11 is treated, for example, with ethyl formate under basic conditions followed by acidification and isolation to form 4-hydroxy quinoline 12. Quinoline 12 may be converted to compounds of the invention in a number of ways. For example, the 4-oxygen is used as a nucleophile in a nucleophilic aromatic substitution reaction to form quinoline-aryl-ether 13. In another example, compound 13 is further derivatized, via removal of protecting group P, to afford compound 14. The 7-hydroxy of compound 14 is alkylated, for example with electrophile E, to provide a compound of the invention. As discussed in relation to Scheme 1, variations on any of the above steps are possible, and intermediates in these schemes, for example compounds 12, 13, and 14 may also be compounds of the invention according to formula I. Also, for example, the 4-hydroxy quinoline compound 12 are converted to a corresponding 4-nitrogen or 4-sulfur quinoline using chemistry well known in the art to make compounds of the invention, or

alternatively the corresponding 4-nitrogen or 4-sulfur quinolines are made via routes analogous to those depicted in Schemes 1 and 2.

Scheme 2

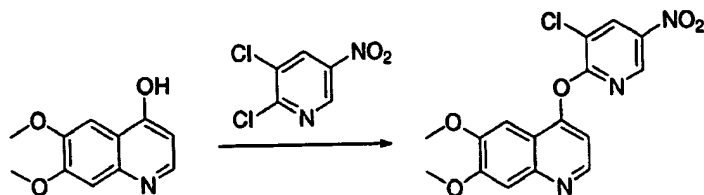


[0209] Schemes 1 and 2 are illustrative of quinolines and quinazolines having oxygen substitution at their respective 6- and 7-positions; the invention is not so limited, but rather is intended to encompass quinolines and quinazolines not necessarily having substitution, oxygen or otherwise, at their respective 6- or 7-positions.

Examples

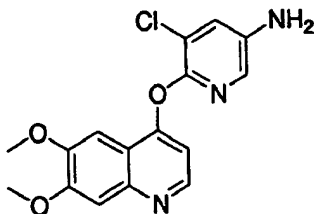
[0210] The following examples serve to more fully describe the manner of using the above-described invention, as well as to set forth the best modes contemplated for carrying out various aspects of the invention. It is understood that these examples in no way serve to limit the true scope of this invention, but rather are presented for illustrative purposes. All references cited herein are incorporated by reference in their entirety. Generally, each example set out below describes a multi-step synthesis as outlined above.

Example 1



[0211] **4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6,7-dimethoxy-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 6,7-dimethoxy-1H-quinolin-4-one (4.5 g, 21.92 mmol, 1.0 eq.), anhydrous acetonitrile (225 mL) and Cs_2CO_3 (7.84 g, 24.06 mmole, 1.1 eq.). The reaction mixture was stirred at room temperature for 5 minutes, followed by addition of 2,3-dichloro-5-nitro-pyridine (4.64 g, 24.03 mmol, 1.1 eq.), prepared according to *Synthesis*, 1990, 6, 499-501. The reaction mixture was heated at 50°C with stirring for 16 hours. The solid was filtered, and then taken up into water to remove Cs_2CO_3 . The solid was filtered again, then dried under vacuum to afford 4-(3-chloro-5-nitro-pyridin-2-yloxy)-6,7-dimethoxy-quinoline (3.402g) as a light yellow solid. More desired product was collected by concentrating down the first acetonitrile filtrate via rotary evaporation, then added small amount of MeOH to the residue to crash out more light yellow solid for filtration (1.788g). The total yield is 5.19 g (65.4%). MS (EI) for $\text{C}_{16}\text{H}_{12}\text{ClN}_3\text{O}_5$: 362.2 (MH^+); ^1H NMR (400 MHz, CDCl_3): 8.91 (d, 1H), 8.77 (d, 1H), 8.69 (d, 1H), 7.50 (s, 1H), 7.21 (d, 1H), 7.20 (s, 1H), 4.06 (s, 3H), 3.97 (s, 3H).

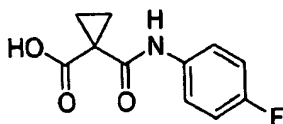
Example 2



[0212] **5-Chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine.** To a round bottom flask equipped with a magnetic stir bar was added 4-(3-chloro-5-nitro-pyridin-2-yloxy)-6,7-dimethoxy-quinoline (5.18 g, 14.31 mmol, 1.0 eq.), iron powder (8.55 g, 0.153 mol, 10.7 eq.), and ammonium formate (8.55g, 0.136 mol, 9.5 eq.), water (170 mL) and toluene (170 mL). The reaction mixture was refluxed for 4 hours. While the mixture was still hot, filtered through celite, then washed with EtOAc. The organic layer was separated,

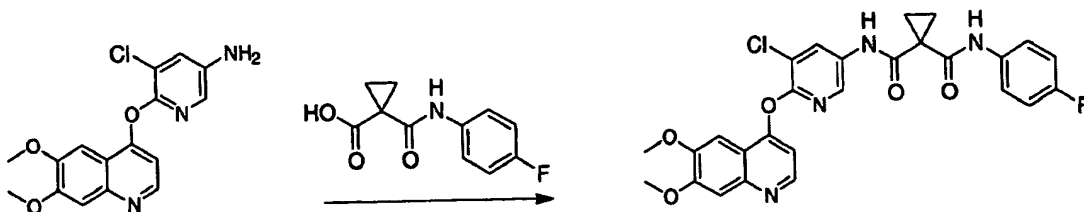
washed with water and brine, dried over sodium sulfate, and concentrated in vacuo to afford 5-chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine as a yellow solid (4.247 g, 89.4%). MS (EI) for $C_{16}H_{14}ClN_3O_3$: 332.1 (MH^+); 1H NMR (400 MHz, $CDCl_3$ w/2drops CD_3OD): 8.48 (d, 1H), 7.70 (d, 1H), 7.55 (s, 1H), 7.38 (s, 1H), 7.23 (d, 1H), 6.57 (d, 1H), 4.04 (s, 3H), 4.03 (s, 3H).

Example 3



[0213] **1-(4-Fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid.** The title compound was prepared based on a modified procedure of Shih and Rankin [*Synthetic Communications*, 1996, 26(4), 833-836]: To a mixture of cyclopropane-1,1-dicarboxylic acid (21.2 g, 0.163 mol, 1.0 eq.) in anhydrous THF (200 mL) under nitrogen was added dropwise triethylamine (16.49 g, 0.163 mol, 1.0 eq.) with stirring for 30 minutes at 0°C, followed by the addition of thionyl chloride (19.39 g, 0.163 mol, 1.0 eq.) with stirring for another 30 minutes at 0°C. To the resulting mixture under nitrogen was added dropwise a solution of 4-fluoroaniline (19.92 g, 0.179 mol, 1.1 eq.) in anhydrous THF (100 mL) with stirring for 1.5 hours at 0°C. The reaction mixture was diluted with ethyl acetate and washed with 1N NaOH. The layers were separated, and the ethyl acetate layer was concentrated in vacuo to give a brownish solid. The brownish solid was washed with small amount of cold ethyl acetate, filtered and dried under vacuum to yield 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid as a white solid (23.71 g, 65.18%). 1H NMR (400 MHz, CD_3OD): 7.57-7.53 (m, 2H), 7.05-7.00 (m, 2H) 1.46-1.43 (m, 2H), 1.40-1.37 (m, 2H).

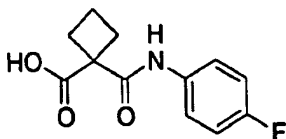
Example 4



[0214] **N-(6-((6,7-Bis(methoxy)quinolin-4-yl)oxy)-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** 5-Chloro-6-(6,7-dimethoxy-quinolin-4-

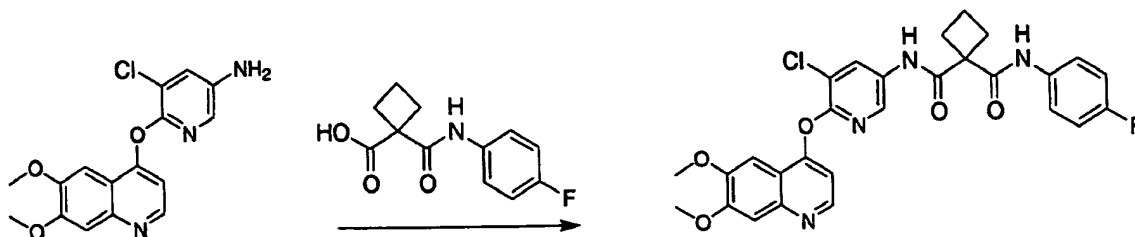
xyloxy)-pyridin-3-ylamine (111.6 mg, 0.336 mmol, 1.0 eq.), 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid (75.1 mg 0.336 mmol, 1.0 eq.), HATU (192 mg, 0.505 mmol, 1.5 eq.), and DIEA (130 mg, 1.01 mmol, 3.0 eq.) were dissolved in DMF (2 mL). The reaction mixture was stirred at ambient temperature for 16 hours. After which time, *ca.* 50 % of the starting material was converted to the product by LC/MS, but some side products were also observed. The crude product was separated by reverse phase preparatory HPLC with gradient B starting at 10% to 90% acetonitrile/25 mM NH_4OAc ramping over 7 minutes with a 9 min. stop time. After lyophilization, the product was isolated as a light yellow solid (76 mg, 42.1%). MS (EI) for $\text{C}_{27}\text{H}_{22}\text{ClFN}_4\text{O}_5$: 537.2 (MH^+); ^1H NMR (400 MHz, CDCl_3): 10.74 (s, 1H), 8.60 (d, 1H), 8.49 (d, 1H), 8.27 (d, 1H), 7.78 (s, 1H), 7.61 (s, 1H), 7.52 (s, 1H), 7.45-7.41 (m, 2H), 7.10-7.00 (m, 2H), 6.92 (d, 1H), 4.08 (s, 3H), 4.04 (s, 3H), 1.94-1.90 (m, 2H), 1.64-1.61 (m, 2H).

Example 5



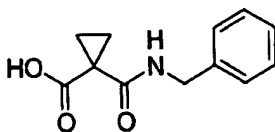
[0215] **1-(4-Fluoro-phenylcarbamoyl)-cyclobutanecarboxylic acid.** To a mixture of cyclobutane-1,1-dicarboxylic acid (10.0 g, 69.4 mmol, 1.0 eq.) in anhydrous THF (100 mL) under nitrogen was added dropwise triethylamine (7.02 g, 69.4 mmol, 1.0 eq.) with stirring for 30 minutes at 0°C , followed by the addition of thionyl chloride (8.25 g, 69.4 mmol, 1.0 eq.) with stirring for another 30 minutes at 0°C . To the resulting mixture under nitrogen was added dropwise a solution of 4-fluoroaniline (8.48 g, 76.3 mmol, 1.1 eq.) in anhydrous THF (50 mL) with stirring for 1.5 hours at 0°C . The reaction mixture was diluted with ethyl acetate and extracted with 2N NaOH. The aqueous phase was titrated with 2N HCl to pH 1-2 and then extracted with ethyl acetate. The organic phase was dried with sodium sulfate and concentrated in vacuo to give 1-(4-fluoro-phenylcarbamoyl)-cyclobutanecarboxylic acid as a light pink solid (5.75 g, 34.9%). ^1H NMR (400 MHz, CDCl_3 w/1drop CD_3OD): 7.53-7.48 (m, 2H), 7.06-7.00 (m, 2H), 2.81-2.63 (m, 4H), 2.14-2.02 (m, 2H).

Example 6



[0216] **N-(6-([6,7-Bis(methoxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide.** 5-Chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine (106 mg, 0.320 mmol, 1.0 eq.), 1-(4-fluoro-phenylcarbamoyl)-cyclobutanecarboxylic acid (113.6 mg 0.479 mmol, 1.5 eq.), HATU (304 mg, 0.800 mmol, 2.5 eq.), and DIEA (124 mg, 0.959 mmol, 3.0 eq.) were dissolved in DMF (2 mL). The reaction mixture was stirred at ambient temperature for 2 hours. After which time, *ca.* 80 % of the starting material was converted to the product by LC/MS. The crude product was separated by reverse phase preparatory HPLC with gradient B starting at 30% to 75% acetonitrile/25 mM NH_4OAc ramping over 10 minutes with a 12 minute stop time. After lyophilization, the product was isolated as a white solid (53.6 mg, 30.4%). MS (EI) for $\text{C}_{28}\text{H}_{24}\text{ClFN}_4\text{O}_5$: 551.2 (MH^+); ^1H NMR (400 MHz, CDCl_3): 9.05 (s, 1H), 8.70 (d, 1H), 8.57 (d, 1H), 8.43 (s, 1H), 7.94 (s, 1H), 7.91 (s, 1H), 7.66 (s, 1H), 7.54-7.52 (m, 2H), 7.15 (d, 1H) 7.16-7.03 (m, 2H), 4.15 (s, 3H), 4.10 (s, 3H), 2.89-2.82 (m, 2H), 2.78-2.70 (m, 2H), 2.10-2.04 (m, 2H).

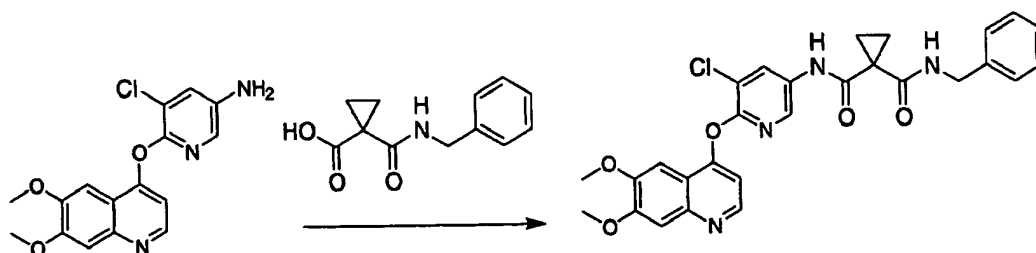
Example 7



[0217] **1-Benzylcarbamoyl-cyclopropanecarboxylic acid.** The title compound was prepared based on a modified procedure of Shih and Rankin [*Synthetic Communications*, 1996, 26(4), 833-836]: To a mixture of cyclopropane-1,1-dicarboxylic acid (5.0 g, 38.4 mmol, 1.0 eq.) in anhydrous THF (50 mL) under nitrogen was added dropwise triethylamine (3.89 g, 38.4 mmol, 1.0 eq.) with stirring for 30 minutes at 0°C , followed by the addition of thionyl chloride (4.57 g, 38.4 mmol, 1.0 eq.) with stirring for another 30 minutes at 0°C . To

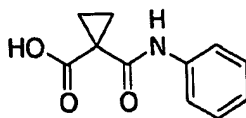
the resulting mixture under nitrogen was added dropwise a solution of benzylamine **5** (4.53 g, 42.3 mmol, 1.1 eq.) in anhydrous THF (25 mL) with stirring for 1.5 hours at 0°C. The reaction mixture was diluted with ethyl acetate and extracted with 2N NaOH (to pH 10). The aqueous phase was titrated with 2N HCl to pH 1-2 and then extracted with ethyl acetate. The organic phase was dried with sodium sulfate and concentrated in vacuo to give 1-Benzylcarbamoyl-cyclopropanecarboxylic acid as a white solid (4.39 g, 52.15%). ¹H NMR (400 MHz, CDCl₃): 8.44 (br s, 1H), 7.37-7.33 (m, 2H), 7.32-7.26 (m, 3H), 1.82-1.70 (m, 4H).

Example 8

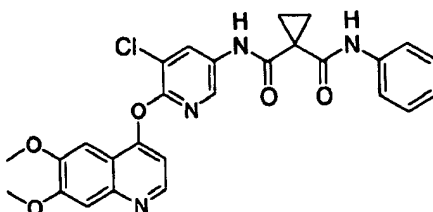


[0218] N-(6-[[6,7-Bis(methoxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(phenylmethyl)cyclopropane-1,1-dicarboxamide.

5-Chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine (100 mg, 0.301 mmol, 1.0 eq.), 1-benzylcarbamoyl-cyclopropanecarboxylic acid (99.1 mg, 0.452 mmol, 1.5 eq.), HATU (286.5 mg, 0.754 mmol, 2.5 eq.), and anhydrous triethylamine (91.5 mg, 0.904 mmol, 3.0 eq.) were dissolved in DMF (2 mL). The reaction mixture was stirred at ambient temperature for 16 hours. After which time, ca. 90 % of the starting material was converted to the product by LC/MS. The crude product was separated by reverse phase preparatory HPLC, eluting with a gradient solvent system of acetonitrile/H₂O/25 mM NH₄OAc. The fractions containing the desired product were combined. After lyophilization, the product was obtained as a white solid (64.6 mg, 40.27%). MS (EI) for C₂₈H₂₅ClN₄O₅: 533.2 (MH⁺); ¹H NMR (400 MHz, CDCl₃): 11.60 (s, 1H), 8.60 (d, 1H), 8.49 (d, 1H), 8.26 (d, 1H), 7.49 (s, 1H), 7.44 (s, 1H), 7.39-7.31 (m, 3H), 7.25 (d, 2H), 6.82 (d, 1H), 5.90 (br s, 1H), 4.47 (d, 2H), 4.04 (s, 3H), 4.02 (s, 3H), 1.87-1.84 (m, 2H), 1.38-1.35 (m, 2H).

Example 9

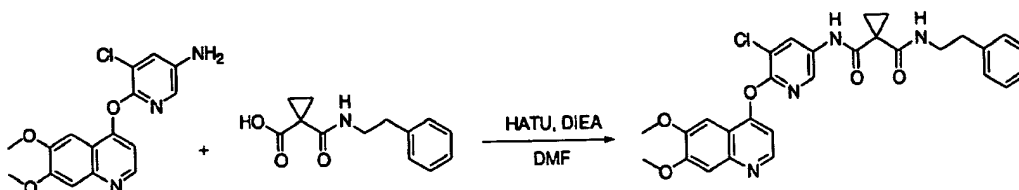
[0219] 1-Phenylcarbamoyl-cyclopropanecarboxylic acid. To a mixture of cyclopropane-1,1-dicarboxylic acid (5.29 g, 40.7 mmol, 1.0 eq.) in anhydrous THF (50 mL) under nitrogen was added dropwise triethylamine (4.12 g, 40.7 mmol, 1.0 eq.) with stirring for 30 minutes at 0°C, followed by the addition of thionyl chloride (4.84 g, 40.7 mmol, 1.0 eq.) with stirring for another 30 minutes at 0°C. To the resulting mixture under nitrogen was added dropwise a solution of phenylamine 9 (4.17 g, 44.8 mmol, 1.1 eq.) in anhydrous THF (25 mL) with stirring for 1.5 hours at 0°C. The reaction mixture was diluted with ethyl acetate and extracted with 2N NaOH (to pH >10). The aqueous phase was titrated with 2N HCl to pH 1-2 and then extracted with ethyl acetate. The organic phase was dried with sodium sulfate and concentrated in vacuo to give 1-phenylcarbamoyl-cyclopropanecarboxylic acid as a white solid (5.08 g, 60.8%). ¹H NMR (400 MHz, CDCl₃): 10.50 (br s, 1H), 7.56-7.54 (m, 2H), 7.35-7.31 (m, 2H), 7.15-7.10 (m, 1H), 1.94-1.91 (m, 2H), 1.82-1.79 (m, 2H).

Example 10

[0220] N-(6-([6,7-Bis(methoxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-phenylcyclopropane-1,1-dicarboxamide. 5-Chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine 4 (100 mg, 0.301 mmol, 1.0 eq.), 1-phenylcarbamoyl-cyclopropanecarboxylic acid 10 (92.8 mg, 0.452 mmol, 1.5 eq.), HATU (286.5 mg, 0.754 mmol, 2.5 eq.), and anhydrous triethylamine (91.5 mg, 0.904 mmol, 3.0 eq.) were dissolved in DMF (2 mL). The reaction mixture was stirred at ambient temperature for 16 hours. After which time, *ca.* 80 % of the starting material was converted to the product by LC/MS. The crude product was separated by reverse phase preparatory HPLC. After lyophilization of the product-containing fractions, N-(6-([6,7-bis(methoxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-phenylcyclopropane-1,1-dicarboxamide was obtained as a white solid (79 mg,

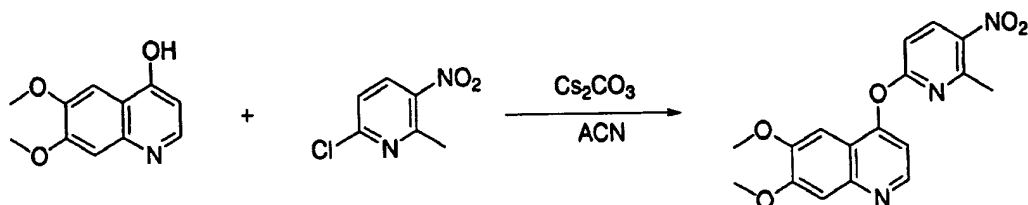
50.6%). MS (EI) for $C_{27}H_{23}ClN_4O_5$: 519.2 (MH^+); 1H NMR (400 MHz, $CDCl_3$ w/drops CD_3OD): 10.82 (s, 1H), 8.61 (d, 1H), 8.48 (d, 1H), 8.24 (d, 1H), 7.73 (s, 1H), 7.50-7.44 (m, 4H), 7.40-7.36 (m, 2H), 7.26-7.19 (m, 1H), 6.86 (d, 1H), 4.05 (s, 3H), 4.02 (s, 3H), 1.92-1.89 (m, 2H), 1.62-1.59 (m, 2H).

Example 11



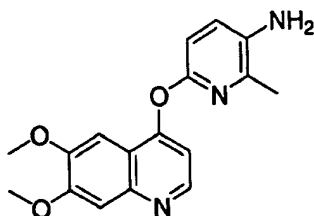
[0221] **N'-(2-phenylethyl)cyclopropane-1,1-dicarboxamide.** 5-Chloro-6-(6,7-dimethoxyquinolin-4-yloxy)-pyridin-3-ylamine (103 mg, 0.31 mmol), HATU (180 mg, 0.47 mmol), and DIEA (0.16 mL, 0.92 mmol) were dissolved in DMF (5 mL). The reaction mixture was stirred at ambient temperature for 15 mins, after which time, 1-phenethylcarbamoylcyclopropanecarboxylic acid (75 mg, 0.32 mmol) was added. The mixture was heated at 60 °C under N_2 for 4 hours. By LC/MS, *ca.* 50 % of the starting material was converted to the product. The reaction mixture was cooled to ambient temperature and diluted with water and ethyl acetate. The layers were separated and the organic layer was extracted 2x with 5% aqueous lithium chloride, 1x with brine, dried over sodium sulfate, filtered, and concentrated *in vacuo* to give a brown solid. The crude product was separated by reverse phase preparatory HPLC. After lyophilization, the product was isolated as a light yellow solid (52 mg, 32%). The quinoline starting material was recovered as a solid after lyophilization (30 mg). 1H NMR (400 MHz, d_6 -DMSO): 10.92 (s, 1H), 8.58 (d, 5.1 Hz, 1H), 8.50 (d, 2.3 Hz, 1H), 8.23 (d, 2.3 Hz, 1H), 8.07 (br s, 1H), 7.44 (s, 1H), 7.36 (s, 1H), 7.30-7.26 (m, 2H), 7.21-7.17 (m, 3H), 6.85 (d, 5.3 Hz, 1H), 3.96 (s, 3H), 3.89 (s, 3H), 3.33-3.31 (m, 2H), 2.75 (t, 7.6 Hz, 2H), 1.38-1.31 (m, 4H); MS (EI) for $C_{29}H_{27}ClN_4O_5$: 547 ($M+H^+$).

Example 12



[0222] **6,7-Dimethoxy-4-(6-methyl-5-nitro-pyridin-2-yloxy)-quinoline.** A mixture of 6,7-dimethoxy-quinolin-4-ol (515 mg, 2.5 mmol), 2-chloro-5-nitro-6-picoline (426 mg, 2.5 mmol), and cesium carbonate (850 mg, 2.6 mmol) in acetonitrile (30 mL) was heated at 70 °C under N_2 with stirring for 24 hours. After cooling to ambient temperature, the reaction was filtered. The filtrate was concentrated in vacuo, and separated by column chromatography on silica (ethylacetate) to give 6,7-dimethoxy-4-(6-methyl-5-nitro-pyridin-2-yloxy)-quinoline (120 mg, 14%). ^1H NMR (400 MHz, d_6 -DMSO): 8.66 (d, 5.1 Hz, 1H), 8.58 (d, 7.0 Hz, 1H), 7.44 (s, 1H), 7.31 (d, 8.2 Hz, 1H), 7.23 (s, 1H), 7.19 (d, 5.1 Hz, 1H), 3.95 (s, 3H), 3.84 (s, 3H), 2.58 (s, 3H); MS (EI) for $\text{C}_{17}\text{H}_{15}\text{N}_3\text{O}_5$: 342 ($\text{M}+\text{H}^+$).

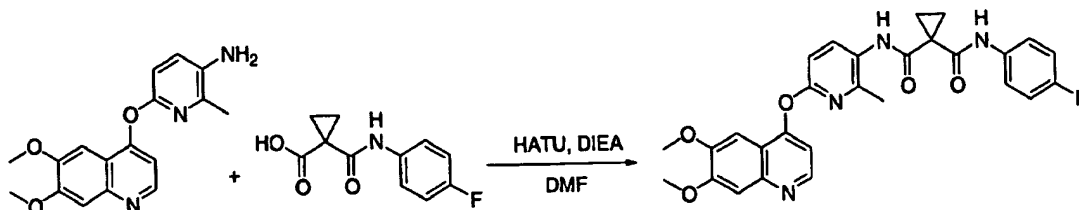
Example 13



[0223] **6-(6,7-Dimethoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine.** 6,7-Dimethoxy-4-(6-methyl-5-nitro-pyridin-2-yloxy)-quinoline (110 mg, 0.32 mmol), platinum sulfide 5% wt on carbon, (20 mg, 27 %), and ammonium formate (135 mg, 2.1 mmol) were slurried in ethanol (20 mL). The reaction mixture was stirred for 4 hours, after which time, the reaction mixture was filtered through Celite. This solid was used for the subsequent synthesis without further purification. An analytically pure product, 6-(6,7-dimethoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine, was obtained by reverse phase preparatory HPLC eluting with a solvent system of acetonitrile/ H_2O /25 mM NH_4OAc . After lyophilization, the product was isolated as a light yellow solid (52 mg, 32%). ^1H NMR (400 MHz, d_6 -DMSO): 8.53 (d, 5.5 Hz, 1H), 7.52 (s, 1H), 7.41 (s, 1H), 7.16 (d, 8.4 Hz, 1H), 6.92 (d, 8.4 Hz, 1H), 6.58 (d, 5.7 Hz,

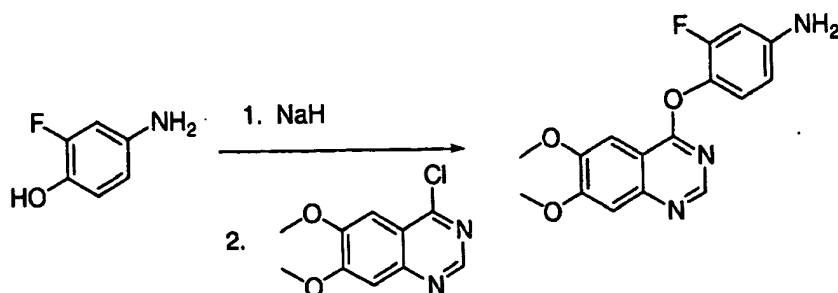
1H), 3.97 (s, 3H), 3.95 (s, 3H), 3.37 (bs s, 2H), 2.23 (s, 3H); MS (EI) for $C_{17}H_{17}N_3O_3$: 312 (MH^+).

Example 14



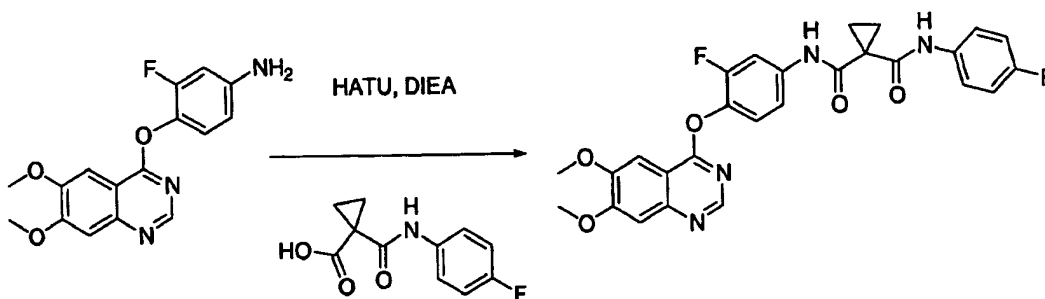
[0224] **N-(6-({[6,7-bis(methoxy)quinolin-4-yl]oxy})-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** 6-(6,7-Dimethoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine (75 mg, 0.24 mmol), HATU (184 mg, 0.48 mmol), and DIEA (0.12 mL, 0.69 mmol) were dissolved in DMF (10 mL). The reaction mixture was stirred at ambient temperature for 15 mins, after which time, 1-(4-fluorophenylcarbamoyl)-cyclopropanecarboxylic acid (59 mg, 0.26 mmol) was added. The mixture was heated at 60 °C under N_2 for 4 hours. By LC/MS, *ca.* 50 % of the starting material was converted to the product. The reaction mixture was cooled to ambient temperature and diluted with water and ethyl acetate. The layers were separated and the organic layer was extracted 2x with 5% aqueous lithium chloride, 1x with brine, dried over sodium sulfate, filtered, and concentrated *in vacuo* to give a brown solid. The crude product was separated by reverse phase preparatory HPLC eluting with a solvent system of acetonitrile/ H_2O /25 mM NH_4OAc . After lyophilization, the product was isolated as a light yellow solid (20 mg, 16%). The quinoline starting material was recovered as a solid after lyophilization (20 mg). 1H NMR (400 MHz, d_6 -DMSO): 10.05 (s, 2H), 8.47 (d, 5.1 Hz, 1H), 7.98 (d, 8.6 Hz, 1H), 7.57-7.55 (m, 2H), 7.32 (s, 1H), 7.32 (s, 1H), 7.10-7.05 (m, 3H), 6.72 (d, 5.1 Hz, 1H), 3.87 (s, 3H), 3.81 (s, 3H), 2.24 (s, 3H), 1.48-1.46 (m, 4H); MS (EI) for $C_{28}H_{25}FN_4O_5$: 517 (MH^+).

Example 15



[0225] **4-(6,7-Dimethoxy-quinazolin-4-yloxy)-3-fluoro-phenylamine.** 4-Amino-2-fluorophenol (2.75g, 21.6mmol) was dissolved in dry DMF (25ml) and cooled in an icebath. NaH (60% dispersion in oil, 1.49g, 37.2mmol) was added slowly with stirring and the mixture stirred at 0C for 10-20min. A suspension of 4-chloro-6,7-dimethoxy-quinazoline (3.60g, 16.1mmol) in dry DMF (75ml) was added and the mixture was stirred for several minutes at 0C and then at room temperature for several hours. The reaction mixture was diluted with H₂O (300ml) and extracted with EtOAc (3x). The combined EtOAc extractions were washed with H₂O (1x), sat'd NaHCO₃ (2x), 10% LiCl (3x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in vacuo* to give 4.83g (95%) of crude 4-(6,7-dimethoxy-quinazolin-4-yloxy)-3-fluoro-phenylamine as a dark brown solid which was used as is without further purification. LC/MS Calcd for [M+H]⁺ 316.1, found 316.1.

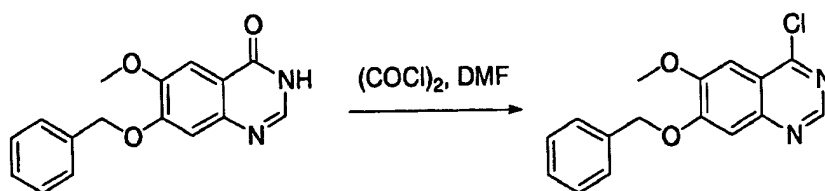
Example 16



[0226] **N-(4-((6,7-bis(methoxy)quinazolin-4-yl)oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** 4-(6,7-Dimethoxy-quinazolin-4-yloxy)-3-fluoro-phenylamine (2.48g, 7.86mmol), 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid (2.32g, 10.4mmol), HATU (5.89g, 15.5mmol), and DIEA (4.00ml, 22.9mmol) were combined in dry DMF (35ml) and stirred at room temperature overnight. The reaction mixture was diluted with H₂O (300ml) and extracted with CHCl₃

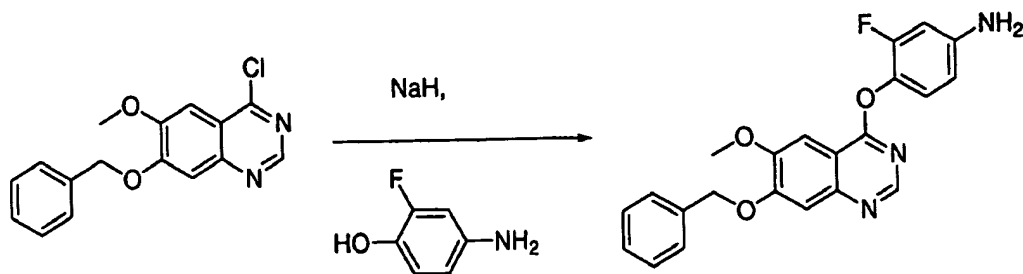
(3x). The combined CHCl_3 extractions were washed with H_2O (1x), sat'd NaHCO_3 (2x), 10% LiCl (3x), sat'd NaCl (1x), dried (Na_2SO_4), and concentrated *in vacuo*. The resulting crude residue was purified by flash chromatography (1:1 hexanes:EtOAc, followed by 37:63 hexanes:EtOAc). The resulting residue was triturated in a combination of EtOAc/ Et_2O /hexanes. The resulting solids were filtered, washed with hexanes and dried under high vacuum to give pure N-(4-{[6,7-bis(methyloxy)quinazolin-4-yl]oxy}-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide (1.76g, 43%). ^1H NMR (400MHz, $\text{DMSO}-d_6$): δ 10.37 (br s, 1H), 10.06 (br s, 1H), 8.56 (s, 1H), 7.84 (m, 1H), 7.65 (m, 2H), 7.57 (s, 1H), 7.45 (m, 3H), 7.16 (t, 2H), 4.00 (s, 3H), 3.99 (s, 3H), 1.48 (br s, 4H). LC/MS Calcd for $[\text{M}+\text{H}]^+$ 521.2, found 521.2.

Example 17



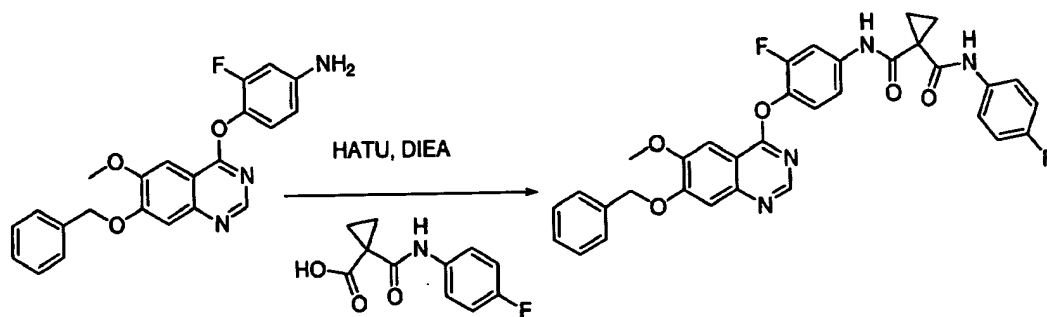
[0227] **7-Benzyloxy-4-chloro-6-methoxy-quinoline.** Dry DMF (8.0ml, 103mmol) was dissolved in dry CHCl_3 (40ml) and cooled in an ice bath. Oxalyl chloride (9.0ml, 105mmol) in CH_2Cl_2 (10ml) was added dropwise with stirring at 0C. When the bubbling had ceased, this solution was added slowly to an ice-cold solution of 7-benzyloxy-6-methoxy-3H-quinazolin-4-one (10.0g, 35.4mmol) in dry CHCl_3 (60ml) and the mixture was then heated to reflux for 2-3hrs. After cooling to room temperature, H_2O (100ml) was added and the phases were separated. The aqueous phase was further extracted with CHCl_3 (2x). The combined CHCl_3 extractions were washed with sat'd NaCl (1x), dried (Na_2SO_4) and concentrated *in vacuo*. The resulting residue was purified by flash chromatography (1:1 hexanes:EtOAc, followed by 100%EtOAc) to give 7-benzyloxy-4-chloro-6-methoxy-quinoline (5.11g, 48%). LC/MS Calcd for $[\text{M}+\text{H}]^+$ 301.1, found 301.1.

Example 18



[0228] **4-(7-Benzyloxy-6-methoxy-quinazolin-4-yloxy)-3-fluoro-phenylamine.** 4-Amino-2-fluoro-phenol (575mg, 4.5mmol) was dissolved in dry DMF (10ml) and cooled in an icebath. NaH (60% dispersion in oil, 372mg, 9.3mmol) was added slowly with stirring and the mixture stirred at 0C for 10-20min. A suspension of 7-benzyloxy-4-chloro-6-methoxy-quinoline (1.12g, 3.7mmol) in dry DMF (30ml) was added and the mixture was stirred at several minutes at 0C and then at room temperature for several hours. The reaction mixture was diluted with H₂O (300ml) and extracted with EtOAc (3x). The combined EtOAc extractions were washed with H₂O (1x), sat'd NaHCO₃ (2x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in vacuo* to give 1.59g (109%) of crude 4-(7-benzyloxy-6-methoxy-quinazolin-4-yloxy)-3-fluoro-phenylamine as a dark brown solid which was used as is without further purification. LC/MS Calcd for [M+H]⁺ 392.1, found 392.2.

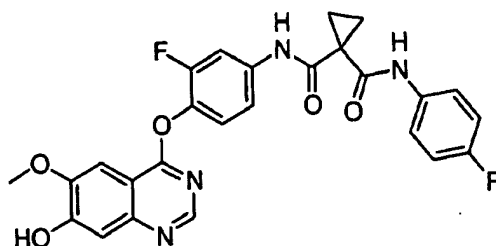
Example 19



[0229] **Cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinazolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide.** 4-(7-Benzyloxy-6-methoxy-quinazolin-4-yloxy)-3-fluoro-phenylamine (1.59g, 4.1mmol), 1-(4-fluorophenyl)-cyclopropanecarboxylic acid (1.21g, 5.4mmol), HATU (3.03g, 8.0mmol), and DIEA (2.0ml, 11.5mmol) were combined in dry DMF (20ml) and stirred at room temperature overnight. The reaction mixture was diluted with H₂O (100ml) and extracted with CHCl₃ (3x). The

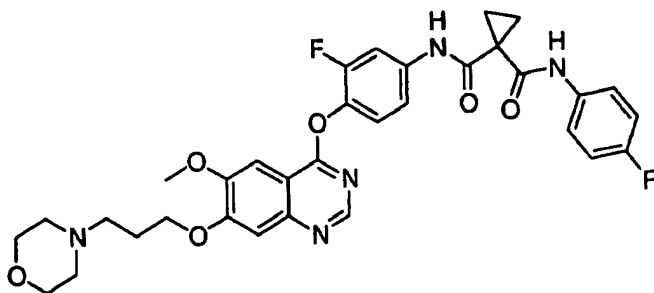
combined CHCl_3 extractions were washed with H_2O (1x), sat'd NaHCO_3 (2x), sat'd NaCl (1x), dried (Na_2SO_4), and concentrated *in vacuo*. The resulting crude residue was purified by flash chromatography (100%hexanes, followed by 1:1 hexanes:EtOAc) to give pure cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinazolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide (1.62g, 67%). LC/MS Calcd for $[\text{M}+\text{H}]^+$ 597.2, found 597.2.

Example 20



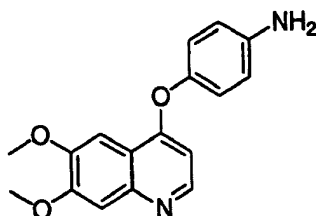
[0230] Cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide. Cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinazolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide (1.53g, 2.6mmol) was dissolved in a combination of EtOAc (25ml), MeOH (25ml), and triethylamine (5ml). To this solution was added 10%Pd/C (600mg). The mixture was stirred under a balloon of H_2 at room temperature and pressure for 1hr. The reaction mixture was filtered through Celite with thorough washing with MeOH and EtOAc. The filtrate was concentrated *in vacuo* to give crude cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide (1.30g, 100%) which was used as is without further purification. LC/MS Calcd for $[\text{M}+\text{H}]^+$ 507.1, found 507.0.

Example 21



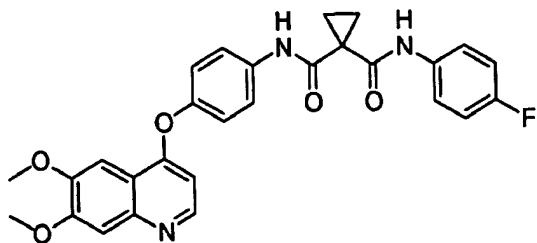
[0231] **Cyclopropane-1,1-dicarboxylic acid {3-fluoro-4-[6-methoxy-7-(3-morpholin-4-yl-propoxy)-quinazolin-4-yloxy]-phenyl}-amide (4-fluoro-phenyl)-amide.** Crude cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide (325mg, 0.64mmol), PS-PPh₃ resin, (loading = 2.33mmol/g, 797mg, 1.86mmol), 3-morpholin-4-yl-propan-1-ol (0.26ml, 1.88mmol), and DEAD (0.31ml, 1.91mmol) were combined in CH₂Cl₂ (10ml) and stirred at room temperature for 1-2hrs. The reaction mixture was filtered and the resin thoroughly washed with CH₂Cl₂. The filtrate was concentrated *in vacuo* and the resulting residue was dissolved in EtOAc and washed with H₂O (4x) and sat'd NaCl (1x) and then extracted with 1N HCl (3x). The combined 1N HCl extractions were washed with EtOAc (2x). The acidic aqueous phase was then basified with 1N NaOH and extracted with EtOAc (3x). The combined EtOAc extractions were washed with H₂O (1x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in vacuo*. The resulting residue was purified by preparative reverse phase HPLC (25mM NH₄OAc/acetonitrile) and the pure fractions were lyophilized to give cyclopropane-1,1-dicarboxylic acid {3-fluoro-4-[6-methoxy-7-(3-morpholin-4-yl-propoxy)-quinazolin-4-yloxy]-phenyl}-amide (4-fluoro-phenyl)-amide (51mg, 13%). ¹H NMR (400MHz, DMSO-*d*₆): d 10.36 (br s, 1H), 10.05 (br s, 1H), 8.55 (s, 1H), 7.83 (m, 1H), 7.64 (m, 2H), 7.57 (s, 1H), 7.44 (m, 3H), 7.18 (t, 2H), 4.27 (m, 2H), 3.99 (s, 3H), 3.61 (m, 6H), 2.40 (m, 4H), 2.01 (m, 2H), 1.47 (m, 4H). LC/MS Calcd for [M+H]⁺ 634.2, found 634.3.

Example 22



[0232] **4-(6,7-Dimethoxy-quinolin-4-yloxy)-phenylamine.** 4-chloro-6,7-dimethoxyquinoline (18.0 g, 53.8 mmol), and 4-nitrophenol (15.0 g, 107.6 mmol) in bromobenzene (100 mL) was heated to 160°C overnight. The solvent was removed *in vacuo*, the residue was taken up in methanol (20 mL), and added to a beaker that contains ethyl ether (300 mL) stirred for 30 minutes and filtered to obtain a yellow solid 29 g. MS (EI) for $C_{17}H_{14}N_2O_5$ (326.3035): 397.2 (MH^+). To 6,7-Dimethoxy-4-(4-nitro-phenoxy)-quinoline (29.0 g, 810 mmol) in toluene (500 mL) and water (500 mL) was added iron (19.2 g, 856 mmol), and ammonium formate (23.6 g, 374 mmol) heated to reflux with mechanical stirring for 24 hours. The reaction mixture was allowed to cool to ambient temperature. The mixture was filtered through celite and washed with hot ethyl acetate (4.5 L) followed by dichloromethane (2 L). The organic layer was washed with brine (3 x 300 mL), dried with magnesium sulfate concentrated *in vacuo*. The solid was treated with 1 N HCl (100 mL), and then basified with 1 N NaOH (100 mL); the mixture was filtered to provide a brown solid 15.0 g 72% yield. 1H -NMR (400 MHz, $CDCl_3$) δ = 8.45 (d, J = 5.2 Hz, 1H), 7.59 (s, 1H), 7.41 (s, 1H), 6.99 (m, 2H), 6.77 (m, 2H), 6.42 (d, J = 5.6 Hz, 1H) 4.05 (m, 6H), 3.73 (s, 2H); MS (EI) for $C_{17}H_{16}N_2O_3$ (296.1161): 297.2 (MH^+).

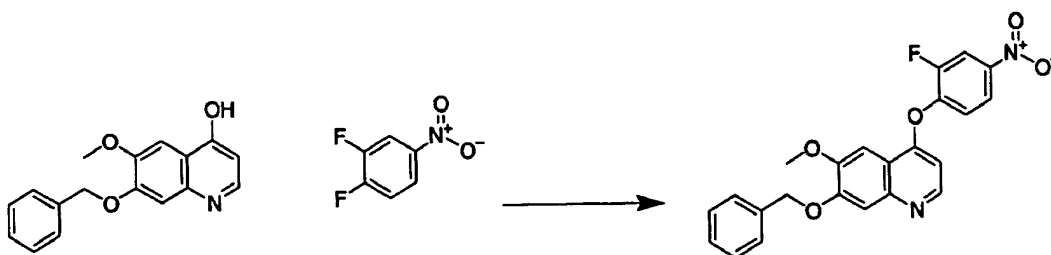
Example 23



[0233] **Cyclopropane-1,1-dicarboxylic acid [4-(6,7-dimethoxy-quinolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide.** To 4-(6,7-Dimethoxy-quinolin-4-yloxy)-phenylamine (1.78 g, 6 mmol), and cyclopropane-1,1-dicarboxylic acid amide (4-fluoro-phenyl)-amide (1.61 g, 7.2 mmol) in DMF was added HATU (3.42 g, 9 mmol), DIEA (1.56 mL, 9 mmol) the

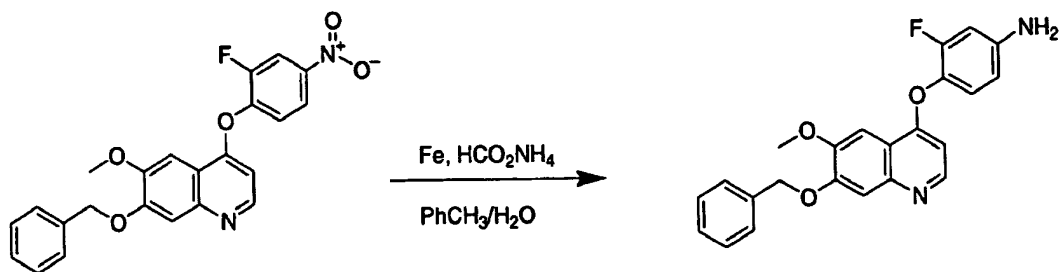
reaction was stirred at room temperature for 3 hours. The volume was reduced *in vacuo*. The solution was diluted with ethyl acetate (200 mL) and washed with 5% LiCl solution (5 x 5 mL), brine (1 x 15mL) and dried over magnesium sulfate. The volume was reduced *in vacuo* and diluted with methanol purified by Prep-HPLC to obtain a white solid 1.48 g 49% yield. ¹H-NMR (400 MHz, d₆-DMSO) δ = 8.44 (d, *J* = 5.2 Hz, 1H), 7.74 (d, *J* = 9.2 Hz, 2H), 7.62 (m, 2H), 7.48 (s, 1H), 7.37 (s, 1H), 7.21 (m, 2H), 7.14 (m, 2H), 6.40 (d, *J* = 5.2 Hz, 1H), 3.93 (s, 6H), 1.47 (s, 4H); MS (EI) for C₂₈H₂₄FN₃O₅ (501.5057): 502.2 (MH⁺).

Example 24



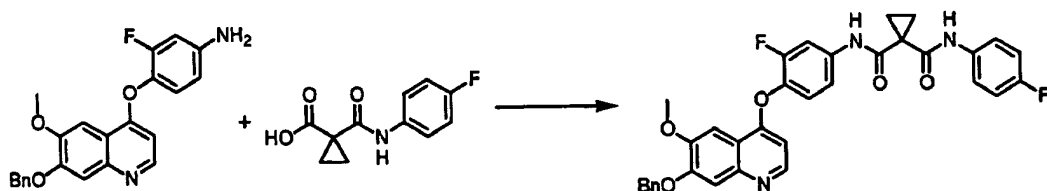
[0234] 7-Benzyl-4-(2-fluoro-4-nitro-phenoxy)-6-methoxy-quinoline. To a solution of 3,4-difluoronitrobenzene (7.0g , 44 mmol), 7-benzyl-4-hydroxy-6-methoxyquinoline (11.3g, 40 mmol) in DMF (300 mL), was added K₂CO₃ (12.4g, 90 mmol) and the solution was stirred at room temperature for 4 h. The volume was reduced to 75 mL) and to the remaining solution was added ethyl acetate (500 mL), washed with 5% LiCl (3 x 100 mL) and dried over anhydrous sodium sulfate. Filtration, concentration, and column chromatography on silica (1:3 hexanes/ethyl acetate) yielded 7-benzyl-4-(2-fluoro-4-nitro-phenoxy)-6-methoxy-quinoline (7.4g, 44%) as a light brown solid. ¹H NMR (400 MHz, d₆-DMSO): 8.43 (d, 1H), 8.33 (dd, 1H), 8.07 (d, 1H), 7.48-7.34 (m, 8H), 6.73 (d, 1H), 4.58 (s, 2H), 3.79 (s, 3H); MS (LCMS) C₂₃H₁₇FN₂O₅: 421 (MH)⁺.

Example 25



[0235] **4-(7-Benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenylamine.** A biphasic solution of compound 7-benzyloxy-4-(2-fluoro-4-nitro-phenoxy)-6-methoxy-quinoline (17.3g, 41.2 mmol), iron powder (9.2g, 0.16 mol), ammonium acetate (10.9g, 0.17 mol), toluene (300mL), and water (300mL) was heated at reflux for 6 h, cooled, filtered through celite and the celite cake was washed with hot ethyl acetate (2L). The layers were separated and the organic layer was dried over anhydrous Na_2SO_4 , filtered and concentrated to yield 4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenylamine (14.8g, 92%) as a yellow solid. ^1H NMR (400 MHz, CDCl_3): 8.46 (d, 1H), 7.61 (s, 1H), 7.51-7.30 (m, 5H), 7.03 (t, 1H), 6.57 (dd, 1H), 6.50 (dd, 1H), 6.39 (d, 2H), 5.33 (s, 2H), 4.06 (s, 3H), 3.18 (br s, 2H); MS (LCMS) $\text{C}_{23}\text{H}_{19}\text{FN}_2\text{O}_3$: 391 (MH) $^+$.

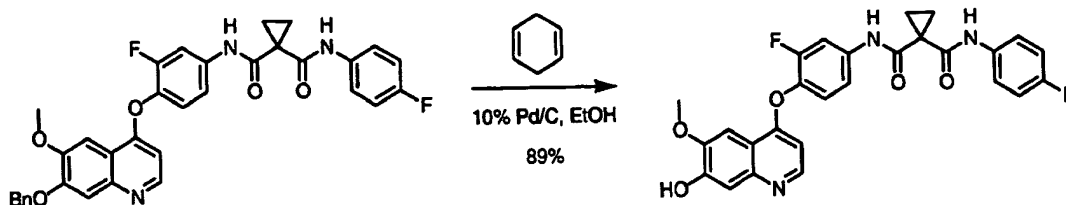
Example 26



[0236] **Cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide.** To a mixture of 4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenylamine (900 mg, 2.3 mmol) and 1-(4-fluorophenylcarbamoyl)-cyclopropanecarboxylic acid (770 mg, 3.5 mmol) in CH_2Cl_2 (20 mL) was added HOBt (621 mg, 4.6 mmol) and EDCI (882 mg, 4.6 mmol). The resulted solution was stirred overnight at rt. The reaction mixture was diluted with CH_2Cl_2 (150 mL) and washed with 50 mL of sat. aqueous NaHCO_3 , 50 mL of 1 N HCl, 50 mL of brine, and dried over Na_2SO_4 . After removal of the solvent, the crude product (86% purity by analytical HPLC) was used in the next reaction or further purified by flash column chromatography (long

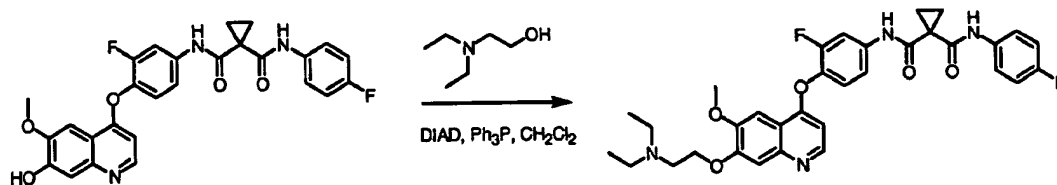
flashing cartridge with 120 g silica gel, hexanes:EtOAc = 1:2). The product was obtained as an off-white solid in 85% yield (1.18 g).

Example 27



[0237] **Cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-phenyl]-amide(4-fluoro-phenyl)-amide.** To a solution of cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide (1.18g, 2.0 mmol) in EtOH (20 mL) was added 1,4-cyclohexadiene (2.0 mL, 20 mmol) and 10% Pd/C (300 mg). The reaction mixture was then heated to reflux and the stirring was continued for 2 h. It was cooled to room temperature, filtered through celite and washed with MeOH. The MeOH solution was then concentrated under reduced pressure. The residue was taken into EtOAc (200 mL). The EtOAc solution was washed with water, and dried over Na₂SO₄. Removal of the solvent under reduced pressure gave 900 mg (89%) of the crude product (90% purity by analytical HPLC), which was used in the next reaction without further purification.

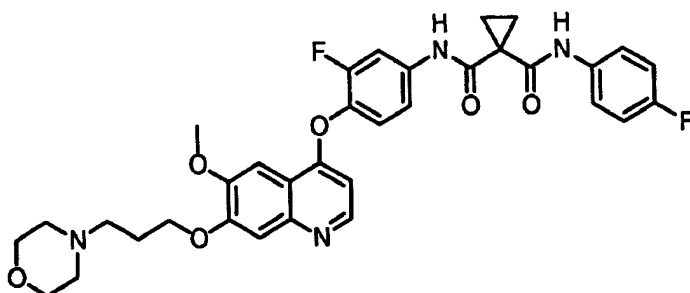
Example 28



[0238] **N-(4-([7-([2-(Diethylamino)ethyl]oxy)-6-(methoxy)quinolin-4-yl]oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** To a mixture of cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-phenyl]-amide(4-fluoro-phenyl)-amide (186 mg, 0.36 mmol) in CH₂Cl₂ (10 mL) was added 2-(diethylamino)ethanol (63 mg, 0.54 mmol), and PPh₃ (141 mg, 0.54 mmol). DIAD (109 mg,

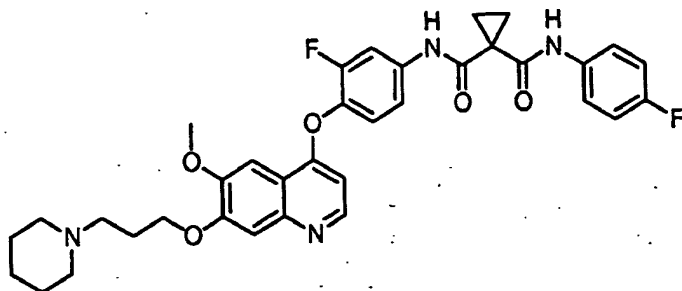
0.54 mmol) was then added as a CH_2Cl_2 (1 mL) solution. The resulted solution was stirred at room temperature for 2 h and the solvent was removed under reduced pressure. To the residue was added 1 N HCl (50 mL), and it was washed with EtOAc (50 mL x 2). The aqueous phase was basified by adding 15% NaOH aqueous solution until pH = 11-13, and then extracted with ether (50 mL x 2). The combined organic layer was dried (MgSO_4), and concentrated in vacuo. The residue was purified on preparative HPLC to give N-(4-([7-([2-(diethylamino)ethyl]oxy)-6-(methyloxy)quinolin-4-yl]oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide (74 mg, 34%) as a pale yellow solid. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 10.40 (br s, 1 H), 10.02 (br s, 1 H), 8.47 (d, $J = 5.2$ Hz, 1 H), 7.91 (br d, $J = 13.9$ Hz, 1 H), 7.54-7.52 (m, 2 H), 7.55-7.50 (m, 1 H), 7.52 (s, 1 H), 7.50-7.40 (m, 1 H), 7.41 (s, 1 H), 7.16 (br t, $J = 8.7$ Hz, 2 H), 6.41 (br d, $J = 4.7$ Hz, 1 H), 4.18 (t, $J = 6.0$ Hz, 2 H), 3.94 (s, 3 H), 2.87 (br t, $J = 6.3$ Hz, 2 H), 2.59 (q, $J = 7.1$ Hz, 4 H), 1.47 (br s, 4 H), 1.00 (t, $J = 7.0$ Hz, 6 H).

Example 29



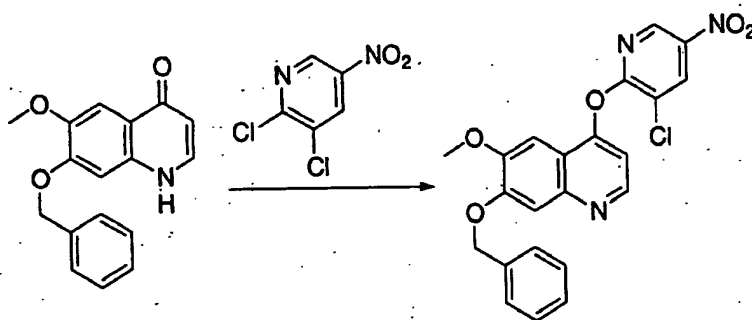
[0239] **N-[3-fluoro-4-((6-(methyloxy)-7-((3-morpholin-4-ylpropyl)oxy)quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared in a similar procedure as above from cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-phenyl]-amide(4-fluoro-phenyl)-amide and 3-Morpholin-4-yl-propan-1-ol. ^1H NMR (400 MHz, CDCl_3): 10.03 (s, 1H), 8.45 (d, 1H), 8.18 (s, 1H), 7.75 (dd, 1H), 7.54 (s, 1H), 7.45-7.41 (m, 2H), 7.24-7.18 (m, 3H), 7.07-7.03 (m, 2H), 6.39 (d, 1H), 4.26 (t, 2H), 4.03, (s, 3H), 3.78-3.75 (m, 4H), 2.68-2.64 (m, 2H), 2.58 (br s, 2H), 2.21-2.14 (m, 4H), 1.83-1.80 (m, 2H), 1.64-1.60 (m, 2H); MS (EI) for $\text{C}_{34}\text{H}_{34}\text{F}_2\text{N}_4\text{O}_6$: 633.3 ($\text{M}+\text{H}^+$).

Example 30



[0240] **N-[3-fluoro-4-({6-(methoxy)-7-[(3-piperidin-1-ylpropyl)oxy]quinolin-4-yl}oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared in a similar procedure as above from cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-phenyl]-amide(4-fluoro-phenyl)-amide and 3-Piperidin-1-yl-propan-1-ol. ¹H NMR (400 MHz, CDCl₃): 10.17 (s, 1H), 8.61 (s, 1H), 8.45 (d, 1H), 7.78 (d, 1H), 7.55 (s, 1H), 7.49-7.44 (m, 3H), 7.31-7.26 (m, 1H), 7.22-7.18 (m, 1H), 7.07-6.98 (m, 2H), 6.40 (d, 1H), 4.26 (t, 2H), 4.01 (s, 3H), 3.15 (t, 2H), 3.06 (br s, 4H), 2.43-2.38 (m, 2H), 1.94-1.90 (m, 4H), 1.83-1.80 (m, 2H), 1.68-1.65 (m, 4H); MS (EI) for C₃₅H₃₆F₂N₄O₅: 631.3 (M+H⁺).

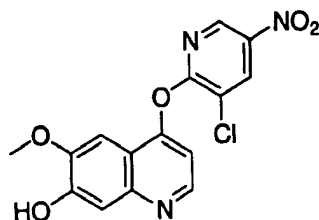
Example 31



[0241] **7-Benzyloxy-4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 7-Benzyloxy-6-methoxy-1H-quinolin-4-one **1** (5.5 g, 19.5 mmol, 1.0 eq.), 2,3-Dichloro-5-nitro-pyridine **2** (4.2 g, 21.7 mmol, 1.1eq), acetonitrile (150ml), DMF (150ml) and cesium carbonate (10 g, 30.7 mmol, 1.5 eq). The mixture was stirred at room temperature overnight. The solids were filtered away and the acetonitrile removed. After removal of MeCN water was added to the solid and allowed to stir for 10 min at which time the solids were filtered and dried under vacuum to

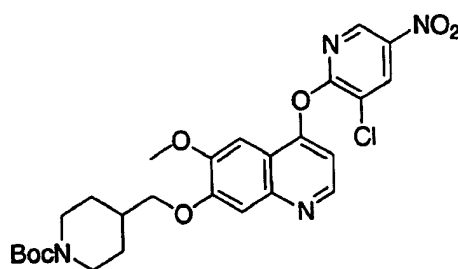
give 7-benzyloxy-4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinoline as a cream colored solid (6.99 g, 82% yield). ^1H NMR (400 MHz, CDCl_3): 8.87 (d, 1H), 8.71 (d, 1H), 8.64 (d, 1H), 7.49 (d, 3H), 7.38 (m, 3H), 7.16 (d, 2H), 5.31 (s, 2H), 3.21 (s, 3H); MS (EI) for $\text{C}_{22}\text{H}_{16}\text{ClN}_3\text{O}_5$: 438 (MH^+).

Example 32



[0242] **4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-ol.** To a round bottom flask equipped with a magnetic stir bar was added 7-Benzyloxy-4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinoline (4.0 g, 9.1 mmol, 1.0eq) and 33% HBr in acetic acid (80 ml). The mixture was stirred at room temperature for 3 hours and diluted with ether to give a pale white solid. The solid was filtered, washed with ether and dried to yield 4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-ol as a pale white solid (3.27 g, 100% yield). ^1H NMR (400 MHz, CDCl_3): 11.87 (bs, 1H), 9.13 (d, 1H), 9.06 (d, 1H), 9.02 (d, 1H), 7.74 (d, 1H), 7.55 (s, 2H), 3.97 (s, 3H); MS (EI) for $\text{C}_{15}\text{H}_{10}\text{ClN}_3\text{O}_5$: 348 (MH^+).

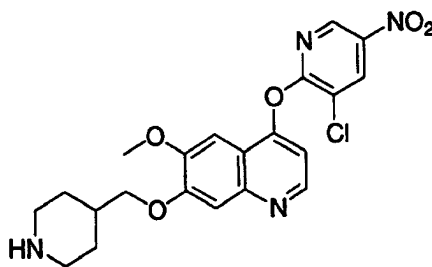
Example 33



[0243] **4-[4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester.** To a round bottom flask equipped with a magnetic stir bar was added 4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-ol (1.5 g, 4.3 mmol), PS- PPh_3 resin, (loading = 2.33mmol/g, 4.3 g, 10 mmol), 4-Hydroxymethyl-piperidine-1-carboxylic acid tert-butyl ester **5** (1.13 g, 5.2mmol), and DIAD (2.13g, 2.1ml, 10.5 mmol) were combined in CH_2Cl_2 (20ml) and stirred at room temperature for 2 hours.

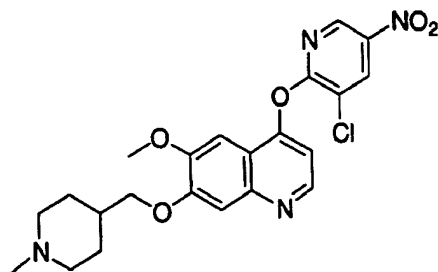
The reaction mixture was filtered and the resin thoroughly washed with CH_2Cl_2 . The filtrate was concentrated *in vacuo* and the resulting residue was dissolved in EtOAc and washed with H_2O (4x) and sat'd NaCl (1x) and then extracted with 1N HCl (3x). The combined 1N HCl extractions were washed with EtOAc (2x). The acidic aqueous phase was then basified with 1N NaOH and extracted with EtOAc (3x). The combined EtOAc extractions were washed with H_2O (1x), sat'd NaCl (1x), dried (Na_2SO_4), and concentrated *in vacuo*. The resulting solid was recrystlized from MeOH to give 4-[4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester as a yellow solid (650 mg, 35%). ^1H NMR (400 MHz, CDCl_3): 8.99 (d, 1H), 8.93 (d, 1H), 8.68 (d, 1H), 7.44 (s, 1H), 7.30 (d, 1H), 7.12 (s, 1H), 4.02 (m, 3H), 3.82 (s, 2H), 2.89 (bs, 1H), 2.49 (d, 3H), 2.02 (bs, 1H), 1.77 (d, 2H), 1.4 (s, 9H), 1.18 (m 2H); MS (EI) for $\text{C}_{26}\text{H}_{29}\text{ClN}_4\text{O}_7$: 545 (MH^+).

Example 34



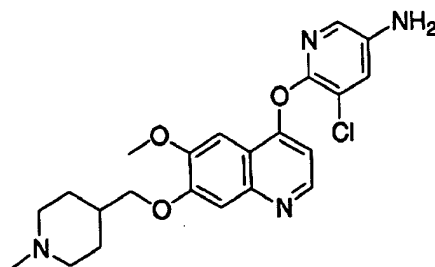
[0244] **4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-7-(piperidin-4-ylmethoxy)-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 4-[4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester (186.6 mg, 0.34 mmol, 1.0eq) and 4M HCl/Dioxane 33%. After 1 hour a white solid was present and this product was filtered, washed with ether, and dried under vacuum to give 4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-7-(piperidin-4-ylmethoxy)-quinoline as a white solid (160 mg, 98%). MS (EI) for $\text{C}_{21}\text{H}_{21}\text{ClN}_4\text{O}_5$: 454 (MH^+).

Example 35



[0245] **4-(3-Chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-7-(1-methyl-piperidin-4-ylmethoxy)-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-7-(piperidin-4-ylmethoxy)-quinoline (0.27g, 0.61 mmol, 1.0 eq.) and acetonitrile/water 1:1 (6 ml). The reaction mixture was then cooled to 0° C and 37% solution of formaldehyde in water was added (0.18 g, 6.1 mmol, 10 eq). While keeping the temperature at 0° C, Na(OAc)₃BH (0.43 g, 1.83 mmol, 3.0 eq) was added. After 1 hour the pH was adjusted to 10 and the aqueous was extracted 2 x DCM (100 ml). After removal of the DCM in vacuo, 4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-7-(1-methyl-piperidin-4-ylmethoxy)-quinoline was obtained as a white solid (0.25 g, 90% yield), which was used for the next reaction without further purification. ¹H NMR (400 MHz, CDCl₃): 8.87 (d, 1H), 8.72 (d, 1H), 8.65 (d, 1H), 7.44 (s, 1H), 7.17 (d, 1H), 7.14 (s, 1H), 4.04 (d, 2H), 3.92 (s, 3H), 2.96 (d, 2H), 2.32 (d, 3H), 2.05 (m, 3H), 1.93 (d, 2H), 1.54 (m, 2H); MS (EI) for C₂₂H₂₃ClN₄O₅: 459 (MH⁺).

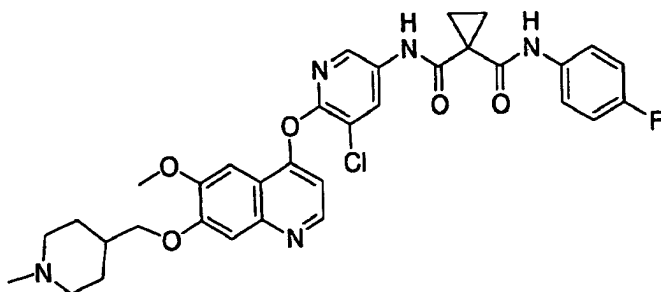
Example 36



[0246] **5-Chloro-6-[6-methoxy-7-(1-methyl-piperidin-4-ylmethoxy)-quinolin-4-yloxy]-pyridin-3-ylamine.** To a round bottom flask equipped with a magnetic stir bar was added 4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-7-(1-methyl-piperidin-4-ylmethoxy)-quinoline (0.25 g, 0.54 mmol, 1.0 eq.), 5% PtS (20% by weight, 50 mg), ammonium formate (0.34g, 5.4 mmol), and ethanol (20 ml). The reaction mixture was heated to reflux for 2 hour. While the

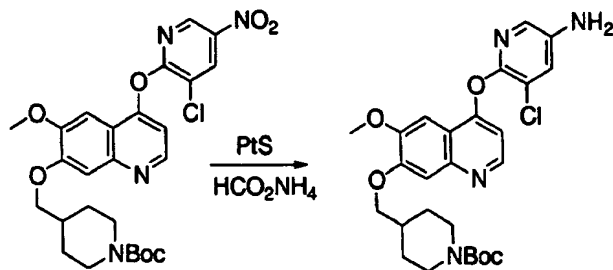
mixture was still hot, filtered through celite, then washed with EtOAc. The organic layer was separated, washed with water and brine, dried over sodium sulfate, and concentrated in vacuo to afford 5-chloro-6-[6-methoxy-7-(1-methyl-piperidin-4-ylmethoxy)-quinolin-4-yloxy]-pyridin-3-ylamine as a cream solid (0.191g, 82%), which was used for the next reaction without further purification. MS (EI) for $C_{22}H_{25}ClN_4O_3$: 429 (MH^+).

Example 37



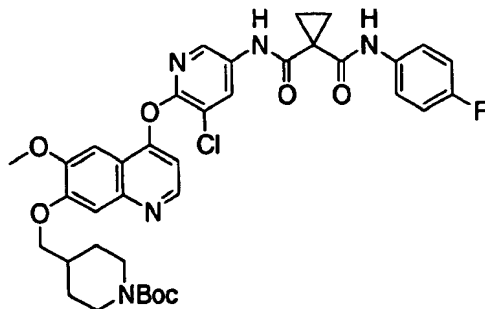
[0247] N-{5-Chloro-6-[(6-(methoxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy)quinolin-4-yl]oxy}pyridin-3-yl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide. To a round bottom flask equipped with a magnetic stir bar were added 5-chloro-6-[6-methoxy-7-(1-methyl-piperidin-4-ylmethoxy)-quinolin-4-yloxy]-pyridin-3-ylamine (0.91 mg, 0.45 mmol, 1.0 eq.), 1-(4-fluorophenylcarbamoyl)-cyclopropanecarboxylic acid (0.198 g, 0.88 mmol), HATU (0.507 g, 1.3 mmol), TEA (0.25 ml, 1.3 mmol), and anhydrous DMF (3 ml). The mixture was stirred at room temperature overnight. The reaction mixture was diluted with H_2O (300ml) and extracted with $CHCl_3$ (3x). The combined $CHCl_3$ extractions were washed with H_2O (1x), sat'd $NaHCO_3$ (2x), 10% LiCl (3x), sat'd NaCl (1x), dried (Na_2SO_4), and concentrated *in vacuo*. The resulting crude residue was purified by HPLC to yield N-{5-chloro-6-[(6-(methoxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy)quinolin-4-yl]oxy}pyridin-3-yl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide as a white solid (0.027 g, 9 % yield). 1H NMR (400 MHz, d_6 -DMSO): 8.54 (d, 1H), 8.50 (d, 1H), 8.37 (d, 1H), 7.61 (m, 2H), 7.39 (s, 1H), 7.33 (d, 1H), 7.17 (m, 2H), 6.82 (d, 1H), 4.08 (d, 2H), 3.87 (s, 3H), 3.17 (d, 2H), 2.55 (s, 3H), 2.38 (d, 1H), 2.05 (d, 3H), 1.85(s, 1H), 1.68 (s, 6H); MS (EI) for $C_{31}H_{31}ClFN_5O_5$: 634 (MH^+).

Example 38



[0248] **4-[4-(5-Amino-3-chloro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester.** To a round bottom flask equipped with a magnetic stir bar was added 4-[4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester (0.6 g, 1.1 mmol, 1.0eq) in toluene (50 mL) and water (50 mL), iron (2.0 g, 36 mmol), and ammonium formate (1.5 g, 22 mmol). The reaction was then heated to reflux for 2 hours. The mixture was filtered hot through celite and washed with hot ethyl acetate (100 ml) followed by dichloromethane (100 ml). The organic layer was washed with brine (3 x 300 mL), dried with sodium sulfate and concentrated *in vacuo* to give 4-[4-(5-amino-3-chloro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester as a brown solid (0.57 g, 100%), which was used for the next reaction without further purification. ^1H NMR (400 MHz, CDCl_3): 8.51 (d, 1H), 7.69 (d, 1H), 7.52 (s, 1H), 7.36 (s, 1H), 7.25 (d, 1H), 7.21 (d, 1H), 7.12 (d, 1H), 6.58 (d, 1H), 4.01 (d, 2H), 3.99 (s, 3H), 3.82 (bs, 2H), 2.75 (t, 2H), 2.34 (s, 1H), 2.16 (m, 1H), 1.88 (d2), 1.34 (s 9H), 1.29 (m, 2H); MS (EI) for $\text{C}_{26}\text{H}_{31}\text{ClN}_4\text{O}_5$: 515 (MH^+).

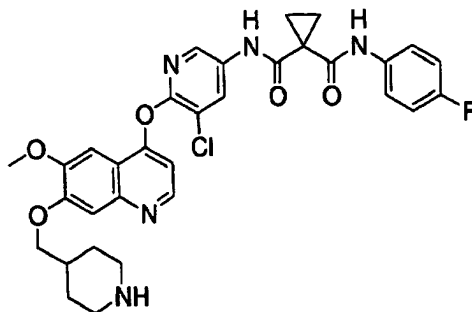
Example 39



[0249] **4-[4-(3-Chloro-5-{{[1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarbonyl]-amino}-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester.** To a round bottom flask equipped with a magnetic stir bar were added 4-[4-(5-

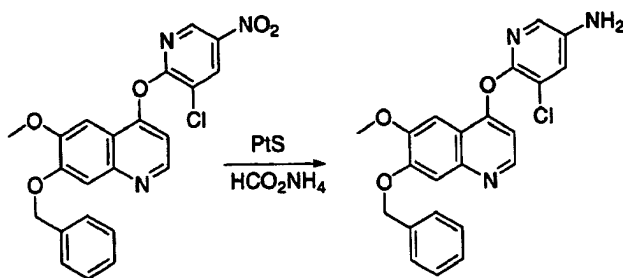
Amino-3-chloro-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester (0.05 g, 0.097 mmol, 1.0 eq.), 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid (0.043 g, 0.19 mmol), HATU (0.11 g, 0.29 mmol), and TEA (0.04 ml, 0.29 mmol) were combined in dry DMF (2 ml) and stirred at room temperature overnight. The reaction mixture was diluted with H₂O (300ml) and extracted with CHCl₃ (3x). The combined CHCl₃ extractions were washed with H₂O (1x), sat'd NaHCO₃ (2x), 10% LiCl (3x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in vacuo*. The resulting crude residue was purified by HPLC to yield 4-[4-(3-Chloro-5-([1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarbonyl]-amino)-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester as a cream solid (0.040 g, 57 % yield). MS (EI) for C₃₇H₃₉ClFN₅O₇: 720 (MH⁺).

Example 40



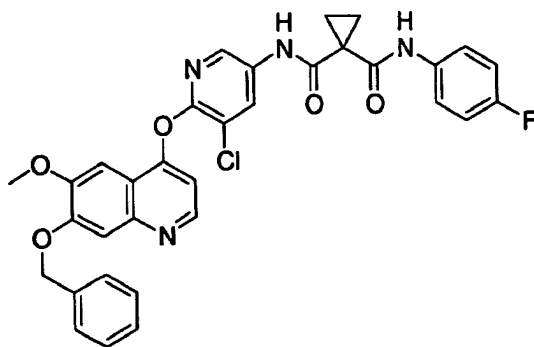
[0250] **Cyclopropane-1,1-dicarboxylic acid {5-chloro-6-[6-methoxy-7-(piperidin-4-ylmethoxy)-quinolin-4-yloxy]-pyridin-3-yl}-amide (4-fluoro-phenyl)-amide.** To a round bottom flask equipped with a magnetic stir bar was added 4-[4-(3-Chloro-5-([1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarbonyl]-amino)-pyridin-2-yloxy)-6-methoxy-quinolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester (0.040 g, 0.055 mmol, 1.0eq) and 4M HCl/Dioxane. After 1 hour a white solid was present and this product was filtered and washed with ether. Upon drying under vacuum a white solid was obtained (0.017 mg, 51%). ¹H NMR (400 MHz, CDCl₃): 8.60 (d, 1H), 8.53 (d, 1H), 8.41 (d, 1H), 7.89 (s, 1H), 7.65 (s, 1H), 7.46 (m, 2H), 7.19 (d, 1H), 7.04 (m, 2H), 4.24 (d, 2H), 4.06 (s, 3H), 3.76 (m, 1H), 3.62 (m, 1H), 3.37 (t, 3H), 2.98 (t, 2H), 2.32 (bs, 1H), 2.18 (d, 2H), 1.79 (m, 5H), 1.25 (s, 1H); MS (EI) for C₃₂H₃₁ClFN₅O₅: 620 (MH⁺).

Example 41



[0251] **6-(7-Benzyloxy-6-methoxy-quinolin-4-yloxy)-5-chloro-pyridin-3-ylamine.** To a round bottom flask equipped with a magnetic stir bar was added 7-benzyloxy-4-(3-chloro-5-nitro-pyridin-2-yloxy)-6-methoxy-quinoline (3.5 g, 8.0 mmol), 5% PtS (20% by weight, 0.7 g), ammonium formate (5.04g, 80 mmol), and ethanol (100 ml). The reaction mixture was heated to reflux for 2 h. The reaction mixture was heated to reflux for 2 hour. While the mixture was still hot, filtered through celite, then washed with EtOAc. The organic layer was separated, washed with water and brine, dried over sodium sulfate, and concentrated in vacuo to afford 6-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-5-chloro-pyridin-3-ylamine as a light brown solid (3.17 g, 98%). ¹H NMR (400 MHz, CDCl₃): 8.49 (d, 1H), 7.68 (d, 1H), 7.55 (s, 1H), 7.49 (d, 2H), 7.43 (s, 1H), 7.33 (m, 2H), 7.24 (m, 1H), 7.19 (d, 1H), 6.57 (d, 1H), 5.3 (s, 2H), 4.02 (s, 3H); MS (EI) for C₃₁H₃₁ClFN₅O₅: 634 (MH⁺). MS (EI) for C₂₂H₁₈ClN₃O₃: 408 (MH⁺).

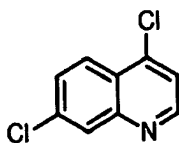
Example 42



[0252] **N-[5-Chloro-6-({6-(methoxy)-7-[(phenylmethyl)oxy]quinolin-4-yl}oxy)pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** To a round bottom flask equipped with a magnetic stir bar was added 6-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-5-chloro-pyridin-3-ylamine (1.5 g, 3.7 mmol, 1.0 eq.), 1-(4-fluorophenylcarbamoyl)-

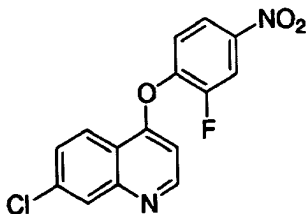
cyclopropanecarboxylic acid (1.23 g, 5.4 mmol), HATU (4.2 g, 11 mmol), TEA (1.5 ml, 10.8 mmol) and anhydrous DMF (10 ml). The reaction mixture was stirred at room temperature overnight. The crude mixture was diluted with H₂O (300ml) and extracted with CHCl₃ (3x). The combined CHCl₃ extractions were washed with H₂O (1x), sat'd NaHCO₃ (2x), 10% LiCl (3x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in vacuo*. The resulting crude residue was purified by recrystallization from MeOH to yield N-[5-chloro-6-({6-(methoxy)-7-[(phenylmethyl)oxy]quinolin-4-yl}oxy)pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide as an off white solid (1.8 g, 81 % yield). ¹H NMR (400 MHz, d₆-DMSO): 10.51 (s, 1H), 10.07 (s, 1H), 8.78 (d, 1H), 8.58 (d, 1H), 8.55 (d, 1H), 8.53 (d, 1H), 8.50 (d, 1H), 8.42 (d, 1H), 7.66 (m, 2H), 7.54 (m, 4H), 7.49 (t, 2H), 7.35 (m, 2H), 7.15 (t, 2H), 6.88 (d, 1H), 5.32 (s, 2H), 3.90 (s, 3H), 1.47 (dd, 4H); MS (EI) for C₃₁H₃₁ClFN₅O₅: 634 (MH⁺). MS (EI) for C₃₆H₂₆ClFN₄O₅: 613 (MH⁺).

Example 43



[0253] **4,7-Dichloroquinoline.** Phosphorus oxychloride (4mL, 429 mmol) was added to 7-chloro-4-hydroxyquinoline 2.86g, 15.9mmol) in a round bottom flask equipped with a reflux condenser. The mixture was heated to reflux for 2h, then allowed to cool to room temperature. The solution was concentrated *in vacuo* to a thick oil, then dumped over cracked ice. The resulting solution was neutralized with saturated NaHCO₃ (aq). The slurry was filtered and washed with water. The solids were dried under vacuum, afforded 4,7-dichloroquinoline as a white solid (2.79g, 88.5% yield).

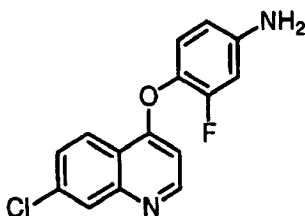
Example 44



[0254] **7-Chloro-4-(2-fluoro-4-nitro-phenoxy)-quinoline.** A slurry of 4,7-dichloroquinoline (755mg, 3.81mmol) and 2-fluoro-4-nitrophenol (719mg, 4.58mmol) in chlorobenzene (15mL)

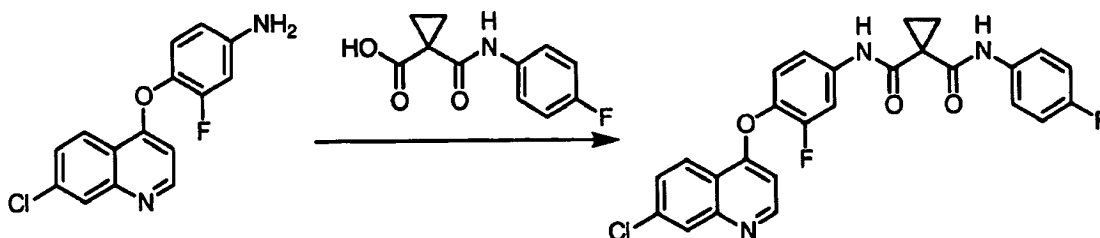
in a round bottom flask equipped with a reflux condenser was heated at reflux for 5 hours. After allowing to cool to room temperature, the slurry was concentrated *in vacuo* yielding crude solids which were purified by flash chromatography (silica gel, 1:3 EtOAc:Hexanes). 7-Chloro-4-(2-fluoro-4-nitro-phenoxy)-quinoline was obtained as a yellow solid (417mg, 34.5% yield). LC/MS calcd. for $[M+1]^+$ 319, found 319.

Example 45



[0255] **4-(7-Chloro-quinolin-4-yloxy)-3-fluoro-phenylamine.** A slurry of 7-Chloro-4-(2-fluoro-4-nitro-phenoxy)-quinoline (417mg, 1.31mmol), iron powder (730mg, 13.1mmol) and ammonium formate (750mg, 11.9mmol) in 1:1 water:toluene (30mL) was heated at reflux for 2 hours. The resulting slurry was filtered while hot over celite, rinsing with hot EtOAc. The organic layer was separated, dried over MgSO₄ and concentrated *in vacuo* yielding 4-(7-chloro-quinolin-4-yloxy)-3-fluoro-phenylamine (458mg, 100% yield) as a brown solid. LC/MS calcd. for $[M+1]^+$ 289, found 289.

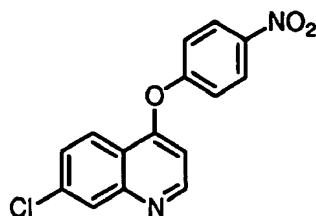
Example 46



[0256] **N-{4-[(7-chloroquinolin-4-yl)oxy]-3-fluorophenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** To a stirred solution of 4-(7-chloro-quinolin-4-yloxy)-3-fluoro-phenylamine (100mg, 0.299mmol), 1-(4-fluoro-phenylcarbonyl)-cyclopropanecarboxylic acid (100mg, 0.448mmol) and TEA (130μL, 0.933mmol) in DMF (1.5mL) was added HATU (286mg, 0.752mmol). The resulting solution was stirred at room temperature for 18 hours. After concentrated in vacuo, the crude mixture was purified by prep HPLC (solvent: MeCN/H₂O/0.01% TFA), affording N-{4-[(7-chloroquinolin-4-yl)oxy]-3-

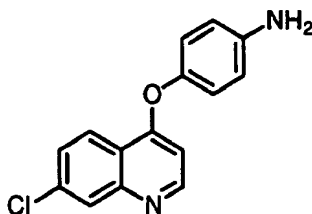
fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide (2.0mg) as a white solid. LC/MS calcd. for $[M+1]^+$ 494, found 494. ^1H NMR (DMSO, d_6): 10.6-10.4 (br., s, 1H), 10.1-10.0 (br., s, 1H), 8.74 (d, 1H), 8.38 (d, 1H), 8.12 (d, 1H), 7.93 (d, 1H), 7.72 (d, 1H), 7.64 (m, 2H), 7.49 (m, 2H), 7.16 (m, 2H), 6.64 (d, 1H), 1.47 (s, 4H).

Example 47



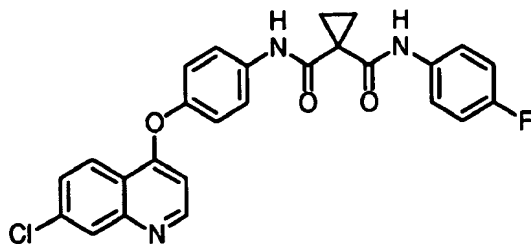
[0257] **7-Chloro-4-(4-nitro-phenoxy)-quinoline.** A slurry of 4,7-dichloroquinoline (1.26mg, 6.37mmol) and 4-nitrophenol (878mg, 6.31mmol) in chlorobenzene (15mL) in a round bottom flask equipped with a reflux condenser was heated at reflux for 18 hours. After allowing to cool to room temperature, the slurry was concentrated *in vacuo* yielding crude solids which were purified by flash chromatography (silica gel, 1:4 EtOAc:Hexanes) to give 7-chloro-4-(4-nitro-phenoxy)-quinoline (281mg, 15% yield) as a white solid. LC/MS calcd. for $[M+1]^+$ 301, found 301.

Example 48



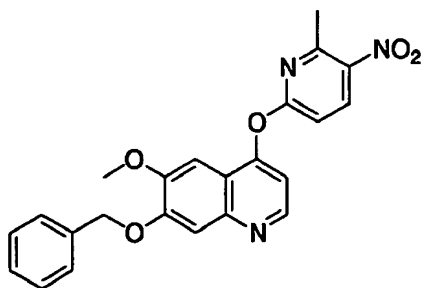
[0258] **4-(7-Chloro-quinolin-4-yloxy)-phenylamine.** A slurry of 7-chloro-4-(4-nitro-phenoxy)-quinoline (341mg, 1.13mmol), iron powder (633mg, 11.3mmol) and ammonium formate (703mg, 11.1mmol) in 1:1 water:toluene (24mL) was heated at reflux for 3 hours. The resulting slurry was filtered while hot over celite, rinsing with hot EtOAc. The organic layer was separated, washed with satd. NaHCO_3 (aq), washed with brine, dried over MgSO_4 and concentrated *in vacuo* yielding 4-(7-chloro-quinolin-4-yloxy)-phenylamine (265mg, 83.5% yield) as a off white solid. LC/MS calcd. for $[M+1]^+$ 271, found 271.

Example 49



[0259] **N-{4-[(7-chloroquinolin-4-yl)oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** To a stirred solution of 4-(7-chloro-quinolin-4-yloxy)-phenylamine (265 mg, 0.979 mmol), 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid (327 mg, 1.47 mmol) and DIEA (500 μ L, 2.86mmol) in DMF (4mL) was added HATU (930mg, 2.45mmol). The resulting solution was stirred at room temperature for 15 hours. The reaction mixture was poured into water and extracted with EtOAc (2X). The combined organic phases were washed with brine, dried over MgSO₄, and concentrated *in vacuo*. The resulting crude yellow solids were further purified by prep HPLC (TFA system). The combined pure fractions were concentrated to remove ACN and then extracted with EtOAc (2X). The combined organic extracts were washed with brine, dried over MgSO₄ and concentrated *in vacuo*, to give N-{4-[(7-chloroquinolin-4-yl)oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide (189mg, 40% yield) as a yellow solid. LC/MS calcd. for [M+1]⁺ 476, found 476. ¹H NMR (DMSO, d₆): 10.27 (s, 1H), 10.05 (s, 1H), 8.83 (d, 1H), 8.43 (d, 1H), 8.15 (d, 1H), 7.80 (m, 3H), 7.65 (m, 2H), 7.31 (dd, 2H), 7.16 (t, 2H), 6.72 (d, 1H), 1.47 (s, 4H).

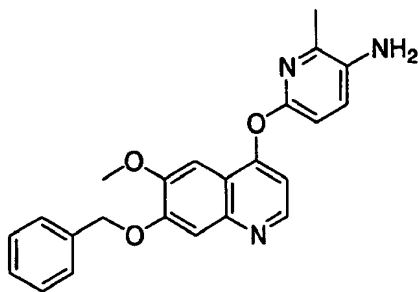
Example 50



[0260] **7-Benzyloxy-6-methoxy-4-(6-methyl-5-nitro-pyridin-2-yloxy)-quinoline.** 7-Benzyloxy-6-methoxy-quinolin-4-ol (1.0 mg, 3.5 mmol), 2-chloro-5-nitro-6-picoline (0.61 mg, 3.5 mmol), and cesium carbonate (1.6 g, 4.9 mmol) were slurried in acetonitrile (20 mL).

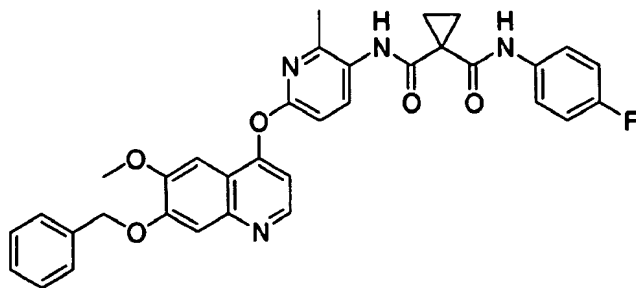
The reaction mixture was heated at 70 °C under N₂ for 24 hours, after which time, the reaction mixture was cooled to ambient temperature. Filtration, concentration, and column chromatography on silica (ethylacetate) gave 7-benzyloxy-6-methoxy-4-(6-methyl-5-nitro-pyridin-2-yloxy)-quinoline (45 mg, 3%). MS (EI) for C₂₃H₁₉N₃O₅: 418 (MH⁺).

Example 51



[0261] **6-(7-Benzyloxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine.** 7-Benzyloxy-6-methoxy-4-(6-methyl-5-nitro-pyridin-2-yloxy)-quinoline (178 mg, 0.43 mmol), platinum sulfide 5% wt on carbon, (16), and ammonium formate (116 mg, 1.8 mmol) were slurried in ethanol (5 mL). The reaction mixture was heated at 80 °C for 5 hours, after which time, the reaction mixture was filtered through Celite. The solvent was removed *in vacuo*. The product, 6-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine as the resultant yellow oil (170 mg, 100%) was used without further purification. MS (EI) for C₁₇H₁₇N₃O₃: 312 (MH⁺).

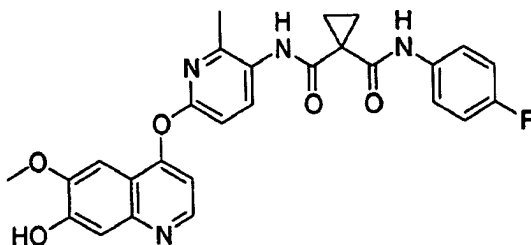
Example 52



[0262] **Cyclopropane-1,1-dicarboxylic acid [6-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-yl]-amide (4-fluoro-phenyl)-amide.** 6-(7-Benzyloxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine (170 mg, 0.43 mmol), HATU (415 mg, 1.1 mmol), and DIEA (0.22 mL, 1.3 mmol) were dissolved in DMF (5 mL). The reaction

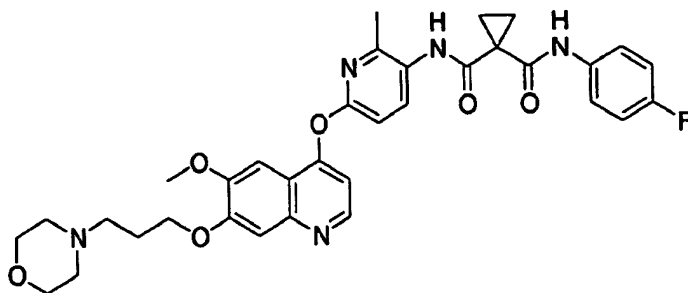
mixture was stirred at ambient temperature for 15 min, after which time, 1-(4-fluorophenylcarbamoyl)-cyclopropanecarboxylic acid (120 mg, 0.54 mmol) was added. The mixture was heated at 70 °C under N₂ for 8 hours. By LC/MS, *ca.* 50 % of the starting material was converted to the product and continued heating for 24 hours did not lead to more product formation. The reaction mixture was cooled to ambient temperature and diluted with water and ethyl acetate. The layers were separated and the organic layer was extracted 2x with 5% aqueous lithium chloride, 1x with brine, dried over sodium sulfate, filtered, and concentrated *in vacuo* to give a brown solid. Filtration, concentration, and column chromatography on silica (3% MeOH/DCM) gave cyclopropane-1,1-dicarboxylic acid [6-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-yl]-amide (4-fluoro-phenyl)-amide (80 mg, 31%). MS (EI) for C₃₄H₂₉N₄O₅: 593 (MH⁺).

Example 53



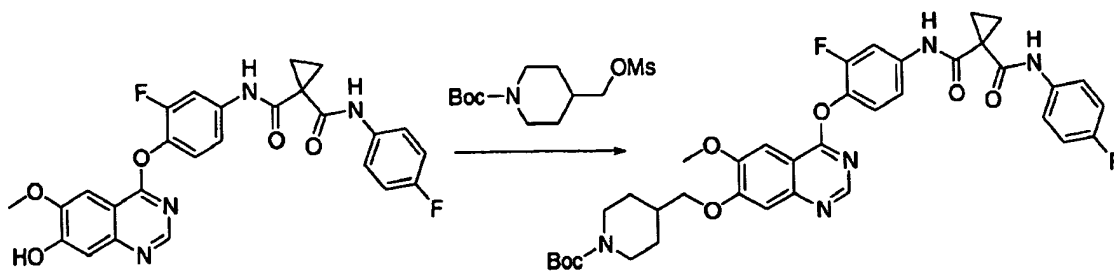
[0263] **Cyclopropane-1,1-dicarboxylic acid (4-fluoro-phenyl)-amide [6-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-yl]-amide.** Cyclopropane-1,1-dicarboxylic acid [6-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-yl]-amide (4-fluoro-phenyl)-amide (80 mg, 0.14 mmol), Pd(OH)₂ 20 % by wt on carbon (20 mg), and acetic acid (0.5 mL) were slurried in methanol (20 mL). The reaction mixture was shaken under an atmosphere of hydrogen (45 p.s.i.) on a Parr Hydrogenation Apparatus. After 3 hours, the mixture was filtered through Celite. Concentration of the solvent *in vacuo* gave cyclopropane-1,1-dicarboxylic acid (4-fluoro-phenyl)-amide [6-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-yl]-amide, which was used without further purification. MS (EI) for C₂₇H₂₃N₄O₅: 503 (MH⁺).

Example 54



[0264] **N-(4-Fluorophenyl)-N'-[2-methyl-6-((6-(methoxy)-7-((3-morpholin-4-yl)propyl)oxy)quinolin-4-yl)oxy]pyridin-3-yl]cyclopropane-1,1-dicarboxamide.** Cyclopropane-1,1-dicarboxylic acid (4-fluoro-phenyl)-amide [6-(7-hydroxy-6-methoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-yl]-amide (85 mg, 0.17 mmol), 4-(3-hydroxypropyl)-morpholine (0.10 mL, 0.72 mmol), and triphenylphosphine (273 mg, 1.0 mmol) were stirred in DCM (5 mL) for 15 mins, after which time, DIAD (0.15 mL, 0.71 mmol) was added. The reaction mixture was stirred at ambient temperature for 24 hours. Filtration, concentration, and column chromatography on silica (4:1 EtOAc:MeOH) gave the product as an off white solid that was 86 % pure by analytical HPLC. This product was further purified by reverse phase preparatory HPLC to give N-(4-fluorophenyl)-N'-[2-methyl-6-((6-(methoxy)-7-((3-morpholin-4-yl)propyl)oxy)quinolin-4-yl)oxy]pyridin-3-yl]cyclopropane-1,1-dicarboxamide as a light yellow solid (12 mg, 9%). ¹H NMR (400 MHz, *d*₆-DMSO): 10.13 (s, 2H), 8.5 (br s, 1H), 8.05 (d, 8.4 Hz, 1H), 7.64-7.61 (m, 2H), 7.39 (s, 1H), 7.36 (s, 1H), 7.17-7.11 (m, 3H), 6.78 (d, 4.9 Hz, 1H), 4.18 (t, 6.2 Hz, 2H), 3.87 (s, 3H), 3.58 (br s, 4H), 3.29 (m, 4H), 2.38 (m, 2H), 2.29 (s, 3H), 1.97 (m, 2H), 1.53-1.52 (m, 4H); MS (EI) for C₃₄H₃₆FN₅O₆: 630 (MH⁺).

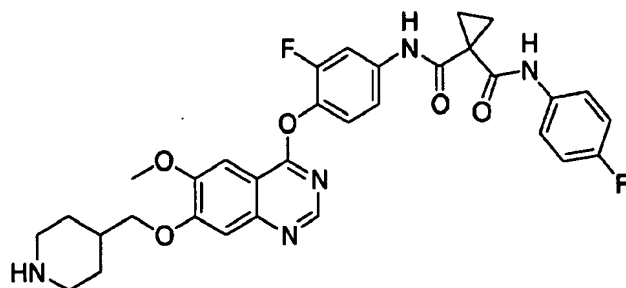
Example 55



[0265] **4-[4-(2-Fluoro-4-[[1-(4-fluoro-phenyl)carbamoyl]-cyclopropanecarbonyl]-amino]-phenoxy)-6-methoxy-quinazolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl**

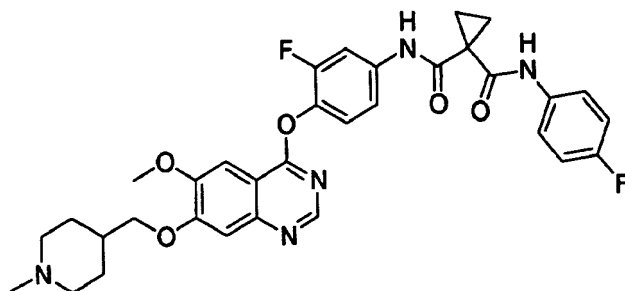
ester. Cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide (325 mg, 0.64 mmol), 4-methanesulfonyloxymethyl-piperidine-1-carboxylic acid tert-butyl ester (193 mg, 0.66 mmol), K_2CO_3 (181 mg, 1.31 mmol) were combined in DMF (5 ml) and heated to 80°C overnight. The reaction was not complete and more 4-methanesulfonyloxymethyl-piperidine-1-carboxylic acid tert-butyl ester (90 mg, 0.31 mmol) and K_2CO_3 (90 mg, 0.65 mmol) were added and heating at 80°C continued for another night. The reaction mixture was allowed to cool to room temperature, then diluted with EtOAc and washed with H_2O (3x), sat'd NaCl (1x), dried (Na_2SO_4) and concentrated *in vacuo*. The resulting crude material was purified by flash chromatography (1:1 hexanes:EtOAc, followed by 1:3 hexanes:EtOAc) to give 4-[4-(2-fluoro-4-{[1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarbonyl]-amino}-phenoxy)-6-methoxy-quinazolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester (273 mg, 60%). LC/MS Calcd for $[M+H]^+$ 704.3, found 704.4.

Example 56



[0266] Cyclopropane-1,1-dicarboxylic acid {3-fluoro-4-[6-methoxy-7-(piperidin-4-ylmethoxy)-quinazolin-4-yloxy]-phenyl}-amide (4-fluoro-phenyl)-amide, TFA salt. 4-[4-(2-Fluoro-4-{[1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarbonyl]-amino}-phenoxy)-6-methoxy-quinazolin-7-yloxymethyl]-piperidine-1-carboxylic acid tert-butyl ester (273 mg, 0.39 mmol) was dissolved in CH_2Cl_2 (8 ml) to which was added TFA (8 ml) and the mixture stirred at room temperature for 1hr. The reaction mixture was concentrated *in vacuo* and the resulting oil triturated with Et_2O . The resulting solids were filtered, washed with Et_2O and dried under high vacuum to give cyclopropane-1,1-dicarboxylic acid {3-fluoro-4-[6-methoxy-7-(piperidin-4-ylmethoxy)-quinazolin-4-yloxy]-phenyl}-amide (4-fluoro-phenyl)-amide, TFA salt (222 mg, 80%). LC/MS Calcd for $[M+H]^+$ 604.2, found 604.3.

Example 57



[0267] N-{3-Fluoro-4-[(6-(methoxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy}quinazolin-4-yl)oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.

Cyclopropane-1,1-dicarboxylic acid {3-fluoro-4-[6-methoxy-7-(piperidin-4-ylmethoxy)-quinazolin-4-yloxy]-phenyl}-amide (4-fluoro-phenyl)-amide, TFA salt (222 mg, 0.31 mmol), H₂O (3 ml), 37% formaldehyde in H₂O (0.18 ml) and acetic acid (27 drops) were combined in acetonitrile (9 ml) to which was slowly added triacetoxyborohydride (561 mg, 2.65 mmol). The mixture was stirred at room temperature for 1-2 hr, then diluted with 1N NaOH and H₂O and extracted with CH₂Cl₂ (3x). The combined CH₂Cl₂ extractions were washed with sat'd NaCl (1x), dried (Na₂SO₄) and concentrated *in vacuo*. The resulting residue was dissolved in a minimum of 1:1 dioxane:EtOAc to which was added 4M HCl in dioxane (1-2 ml). The resulting solids were filtered, washed with EtOAc and dried under high vacuum to give N-{3-fluoro-4-[(6-(methoxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy}quinazolin-4-yl)oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide, HCl salt (167 mg, 83%).

¹HNMR (400MHz, DMSO-d₆): δ 10.40 (s, 1H), 10.17 (br s, 1H) 10.07 (s, 1H), 8.61 (s, 1H), 7.85 (m, 1H), 7.65 (m, 2H), 7.48 (m, 2H), 7.42 (t, 1H), 7.16 (t, 2H), 4.12 (2, 2H), 4.00 (s, 3H), 3.46 (m, 2H), 2.99 (m, 2H), 2.73 (d, 3H), 2.13 (m, 1H), 2.01 (m, 2H), 1.63 (m, 2H), 1.47 (m, 4H). LC/MS Calcd for [M+H]⁺ 618.2, found 618.3.

Synthesis of Bridged Bicyclics

[0268] The following describes synthesis of bridged bicyclics with appended leaving groups for use as, for example, alkylating agents. In the context of this invention, these alkylating agents are used, for example, to alkylate the quinazoline or quinolines on the 6- or 7-oxygens to make compounds of the invention. The invention is not limited to alkylation chemistry to

append such bridged bicyclics, but rather the aforementioned description is meant only to be illustrative of an aspect of the invention.

Example 58

[0269] **1,4:3,6-dianhydro-2-*O*-methyl-5-*O*-(methylsulfonyl)-D-glucitol:** To a solution of 1,4:3,6-dianhydro-2-*O*-methyl-D-glucitol (1.19g, 7.4 mmol) in dichloromethane was added pyridine (1mL, 12.36 mmol) followed by methanesulfonyl chloride (0.69mL, 8.92 mmol) and the mixture was allowed to stir at room temperature over 12 hours. The solvent was removed and the amorphous residue was partitioned with ethyl acetate and 0.1M aqueous hydrochloric acid. The aqueous phase was extracted once with additional ethyl acetate and the combined organic layers were washed with saturated aqueous sodium chloride then dried over anhydrous magnesium sulfate. Filtration and concentration followed by drying *in vacuo* afforded 1,4:3,6-dianhydro-2-*O*-methyl-5-*O*-(methylsulfonyl)-D-glucitol (1.67g, 94% yield) as a colorless oil. GC/MS calculated for C₈H₁₄SO₆: 238 (M⁺).

Example 59

[0270] **1,4:3,6-dianhydro-5-*O*-(phenylcarbonyl)-D-fructose ethylene glycol acetal:** A solution of 1,4:3,6-dianhydro-5-*O*-(phenylcarbonyl)-D-fructose (2.00g, 8.06 mmol), ethylene glycol (5.00g, 80.6 mmol), and *p*-toluenesulfonic acid (1.53g, 8.06 mmol) in benzene (100mL) was refluxed for 90 min using a Dean-Stark Trap apparatus. The reaction mixture was diluted with ethyl acetate (100mL), washed with saturated aqueous sodium bicarbonate (2 x 50mL) then brine (50mL), and dried over anhydrous sodium sulfate. Filtration, concentration and column chromatography on silica (1:1 hexane/ethyl acetate) provided 1.44g (61% yield) of 1,4:3,6-dianhydro-5-*O*-(phenylcarbonyl)-D-fructose ethylene glycol acetal as a colorless solid. ¹H NMR (400 MHz; CDCl₃): 8.08 (m, 2H), 7.58 (m, 1H), 7.54 (m, 2H), 5.38 (dd, 1H), 4.97 (t, 1H), 4.21-4.02 (m, 7H), 3.86 (d, 1H), 3.75 (d, 1H).

Example 60

[0271] **1,4:3,6-dianhydro-D-fructose ethylene glycol acetal:** To a solution of 1,4:3,6-dianhydro-5-*O*-(phenylcarbonyl)-D-fructose ethylene glycol acetal (1.44g, 4.93 mmol) in methanol (40mL) was added 50% aqueous sodium hydroxide (0.38 g, 4.75 mmol) and the mixture was stirred at room temperature for 30 minutes. Neutralization with 1M HCl, followed by concentration and column chromatography on silica (1:2 hexane/ethyl acetate)

provided 0.74g (80% yield) of 1,4:3,6-dianhydro-D-fructose ethylene glycol acetal as a colorless solid. ¹H NMR (400 MHz; CDCl₃): 4.60 (t, 1H), 4.32 (m, 1H), 4.14 (d, 1H), 4.05-3.98 (m, 5H), 3.82 (s, 2H), 3.62 (dd, 1H), 2.65 (d, 1H).

[0272] **1,4:3,6-dianhydro-5-O-(methylsulfonyl)-D-fructose ethylene glycol acetal:** To a solution of 1,4:3,6-dianhydro-D-fructose ethylene glycol acetal (0.74g, 3.93 mmol) and triethylamine (1.20g, 11.86 mmol) in dichloromethane (40mL) was added methanesulfonyl chloride (0.90g, 7.88 mmol) at 0°C under nitrogen. The solution was warmed to room temperature and stirred for 13 h. Dichloromethane (50mL) was added, and the organic layer was washed with saturated aqueous sodium bicarbonate (30mL), water (30mL), and brine (30mL) then dried over anhydrous sodium sulfate. Filtration and concentration provided 1.02g (97%) of 1,4:3,6-dianhydro-5-O-(methylsulfonyl)-D-fructose ethylene glycol acetal as a yellow oil. ¹H NMR (400 MHz; CDCl₃): 5.08 (m, 1H), 4.82 (t, 1H), 4.13 (dd, 1H), 4.04 (m, 4H), 3.93 (dd, 1H), 3.87 (d, 1H), 3.81 (d, 1H), 3.13 (s, 3H).

Example 61

[0273] **1,4:3,6-dianhydro-2-deoxy-2-methylidene-D-arabino-hexitol:** To a solution of 1,4:3,6-dianhydro-2-deoxy-2-methylidene-5-O-(phenylcarbonyl)-D-arabino-hexitol (329mg, 1.34 mmol) in methanol (10mL) was added 50% aqueous sodium hydroxide (95mg, 1.19 mmol) and the mixture was stirred at room temperature for 30 minutes. Neutralization with 4M hydrogen chloride in 1,4-dioxane followed by concentration and column chromatography on silica (1:1 hexane/ethyl acetate) provided 141mg (74%) of 1,4:3,6-dianhydro-2-deoxy-2-methylidene-D-arabino-hexitol as a colorless solid. ¹H NMR (400 MHz; CDCl₃): 5.37 (m, 1H), 5.20 (m, 1H), 4.80 (m, 1H), 4.54 (m, 2H), 4.43 (m, 1H), 4.26 (m, 1H), 3.95 (dd, 1H), 3.54 (dd, 1H), 2.70 (d, 1H).

[0274] **1,4:3,6-dianhydro-2-deoxy-2-methylidene-5-O-(methylsulfonyl)-D-arabino-hexitol:** To a solution of 1,4:3,6-dianhydro-2-deoxy-2-methylidene-D-arabino-hexitol (135mg, 0.95 mmol) and triethylamine (288mg, 2.85 mmol) in dichloromethane (10mL) was added methanesulfonyl chloride (222mg, 1.94 mmol) at 0°C under nitrogen. The solution was warmed to room temperature and stirred for 18 h. Dichloromethane (50mL) was added and the organic layer was washed with saturated aqueous sodium bicarbonate (2 x 25mL), water (25mL) and brine (25mL) then dried over anhydrous sodium sulfate. Filtration and concentration provided 213mg (72%) of 1,4:3,6-dianhydro-2-deoxy-2-methylidene-5-O-

(methylsulfonyl)-D-*arabino*-hexitol as a yellow oil. ^1H NMR (400 MHz; CDCl_3): 5.40 (m, 1H), 5.23 (m, 1H), 5.04 (m, 1H), 4.85 (m, 1H), 4.73 (t, 1H), 4.58 (m, 1H), 4.41 (m, 1H), 4.08 (dd, 1H), 3.86 (dd, 1H), 3.14 (s, 3H).

Example 62

[0275] **1,4:3,6-dianhydro-2-deoxy-5-*O*-(phenylcarbonyl)-L-*arabino*-hex-1-enitol:** To a mixture of 1,4:3,6-dianhydro-5-*O*-(phenylcarbonyl)-(D)-glycitol (4.32g, 17.3 mmol), triethylamine (4.91 mL, 35.3 mmol) and 4-dimethylaminopyridine (0.63g, 5.2 mmol) in dichloromethane (50 mL) at -10° to -15° was added trifluoromethanesulfonic anhydride (3.48mL, 20.7 mmol) dropwise over ten minutes and the resulting mixture was stirred at this temperature for 3 hours. The mixture was poured into 100 mL of ice-water and extracted with dichloromethane (3 x 50 mL). The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, filtered then concentrated. The crude triflate was suspended in toluene (50 mL) followed by addition of 1,8-diazabicyclo[4,5,0]undec-7-ene (5.25 mL, 34.6 mmol) and the mixture was stirred at room temperature for 18 hours. The reaction mixture was poured into ice-water and partitioned then the aqueous portion was extracted with dichloromethane (3 x 50 mL). The combined organic portion was washed with brine, dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by flashed chromatography (silica gel, 5-20% ethyl acetate-hexane) to give 1,4:3,6-dianhydro-2-deoxy-5-*O*-(phenylcarbonyl)-L-*arabino*-hex-1-enitol, as a white solid, 3.10g, 77% yield. ^1H NMR (400MHz; CDCl_3): 8.08-8.06 (m, 2H), 7.61-7.57 (m, 1H), 7.56-7.43 (m, 2H), 6.62-6.61 (d, 1H), 5.48-5.46 (m, 1H), 5.32-5.26 (m, 1H), 5.13-5.10 (m, 2H), 4.18-4.14 (tr, 1H), 3.61-3.56 (tr, 1H).

Example 63

[0276] **Methyl 3,6-anhydro-5-*O*-(phenylcarbonyl)- β -L-glucofuranoside:** To a solution of 1,4:3,6-dianhydro-2-deoxy-5-*O*-(phenylcarbonyl)-L-*arabino*-hex-1-enitol (1.00g, 4.3 mmol) in methanol (17 mL) at -4°C was added 3-chloroperoxybenzoic acid (85%, 1.35g, 8.6 mmol), and the resulting mixture was slowly warmed to room temperature and stirred for 18 hours. The reaction mixture was concentrated, diluted with dichloromethane (50 mL), washed with saturated aqueous sodium bicarbonate solution, dried over sodium sulfate, filtered and concentrated. The residue was purified by flash chromatography (silica gel, 25-60% ethyl acetate-hexane) to give methyl 3,6-anhydro-5-*O*-(phenylcarbonyl)- β -L-glucofuranoside as a

white solid, 1.03g, 83% yield. ¹H NMR (400MHz; CDCl₃): 8.11-8.08 (d, 2H), 7.61-7.56 (tr, 1H), 7.48-7.44 (m, 2H), 5.24-5.17 (m, 2H), 4.96 (s, 1H), 4.57-4.56 (d, 1H), 4.27 (s, 1H), 4.22-4.18 (dd, 1H), 4.08-4.04 (dd, 1H) 3.36 (s, 3H).

[0277] Methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(phenylcarbonyl)-β-L-glucofuranoside: A mixture of methyl 3,6-anhydro-5-*O*-(phenylcarbonyl)-β-L-glucofuranoside (1.03g, 3.7 mmol), silver (I) oxide (0.85g, 3.7 mmol) and methyl iodide (0.34 mL, 5.5 mmol) in DMF (2 mL) was heated at 60°C for 1 hour. After cooling to room temperature the reaction mixture was diluted with ethyl acetate (50 mL), filtered over celite, adsorbed on silica gel (10g) and purified by flash chromatography (silica gel, 5-30% ethyl acetate-hexane) to give methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(phenylcarbonyl)-β-L-glucofuranoside as a colorless oil, 0.82g, 76% yield. ¹H NMR (400MHz; CDCl₃): 8.11-8.09 (d, 2H), 7.60-7.56 (m, 1H), 7.46-7.44 (m, 2H), 5.24-5.20 (m, 1H), 5.18-5.09 (tr, 1H), 4.99 (s, 1H), 4.61-4.60 (d, 1H), 4.21-4.17 (tr, 1H), 4.08-4.03 (tr, 1H), 3.81 (s, 1H), 3.40 (s, 3H), 3.57 (s, 3H).

[0278] Methyl 3,6-anhydro-2-*O*-methyl-α-D-idofuranoside: A solution of methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(phenylcarbonyl)-β-L-glucofuranoside (820mg, 3.1mmol) and 50% sodium hydroxide (248 mg, 3.1 mmol) in methanol (10mL) was stirred at room temperature for 30 minutes. The material was adsorbed on silica gel (5g) and passed through a short column (15% ethyl acetate in hexanes to 5% methanol in ethyl acetate) to give methyl 3,6-anhydro-2-*O*-methyl-α-D-idofuranoside as a colorless oil, 420 mg, 85% yield. ¹H NMR (400MHz; CDCl₃): 5.04 (s, 1H), 5.84-5.81 (tr, 1H), 4.44-4.42 (tr, 1H), 4.25-4.19 (m, 1H), 3.85-3.75 (m, 1H), 3.49 (s, 3H), 3.43 (s, 3H), 2.75-2.72 (d, 1H).

[0279] Methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(methylsulfonyl)-β-L-glucofuranoside: Methyl 3,6-anhydro-2-*O*-methyl-α-D-idofuranoside (420 mg, 2.6 mmol) was dissolved in dichloromethane (10 mL) and pyridine (0.36 mL, 3.7 mmol) at 0°C. Methanesulfonyl chloride (0.14 mL, 3.1 mmol) was added and the resulting mixture was stirred at 0°C for 1 hour then at room temperature for 2 hours. The reaction mixture was washed with water and saturated aqueous sodium bicarbonate solution, dried over anhydrous sodium sulfate, filtered and concentrated to give methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(methylsulfonyl)-β-L-glucofuranoside as a colorless oil, 669mg, 95% yield, which was used without further purification.

Example 64

[0280] **3,6-anhydro-5-*O*-(phenylcarbonyl)- α -L-glucofuranose:** A mixture of osmium tetroxide (4% in water, 0.25 mL, 0.03 mmol) and N-methylmorpholine (505 mg, 4.3 mmol) in 3 mL of 50% acetone in water was warmed to 60°C. A solution of 1,4:3,6-dianhydro-2-deoxy-5-*O*-(phenylcarbonyl)-L-*arabino*-hex-1-enitol (2.00g, 8.6 mmol) in 6 mL of 50% acetone in water was added over 3 hours. During this time an additional amount of N-methylmorpholine (1.01g, 8.6 mmol) was added in small portions periodically. Upon completion of the addition process the reaction was stirred for another hour and cooled to room temperature. The crude mixture was applied to a column of silica gel and flashed (0-6% methanol in 1:1 ethyl acetate:hexane) to give 3,6-anhydro-5-*O*-(phenylcarbonyl)- α -L-glucofuranose as a white solid, 1.5g, 65% yield. ¹H NMR (400MHz; DMSO-*d*₆): 8.01-7.95, (m, 2H), 7.68-7.66 (m, 1H), 7.57-7.53 (m, 2H), 5.18-5.11 (m, 2H), 4.85-4.81 (m, 1H, m), 4.37-4.35 (m, 1H), 4.05-3.96 (m, 2H), 3.85-3.83 (m, 1H).

[0281] **3,6-anhydro-2-*O*-methyl-5-*O*-(phenylcarbonyl)- α -L-glucofuranoside:** 3,6-Anhydro-5-*O*-(phenylcarbonyl)- α -L-glucofuranose (576 mg, 2.2 mmol) was added to a mixture of sodium hydride (60% oil dispersion, 346 mg, 8.7 mmol) and methyl iodide (0.54mL, 8.7 mmol) in 5 mL of DMF at 0°C and the resulting mixture was stirred for 1 hour. The reaction mixture was diluted with ethyl acetate and quenched with water (5 mL). The aqueous portion was extracted with ethyl acetate (3 x 5 mL). The combined organic portion was washed with brine, dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flashed chromatography (silica gel, 5-20% ethyl acetate in hexane) to give 3,6-anhydro-2-*O*-methyl-5-*O*-(phenylcarbonyl)- α -L-glucofuranoside as a white solid, 270 mg, 42% yield. ¹H NMR (400MHz; CDCl₃): 8.09-8.07 (m, 2H), 7.61-7.57 (m, 1H), 7.48-7.27 (m, 2H), 5.25-5.22 (m, 1H), 5.07-5.06 (d, 1H), 4.94-4.91 (m, 1H), 4.73-4.71 (m, 1H), 4.20-4.16 (m, 1H), 3.96-3.94 (m, 1H), 3.85-3.83 (tr, 1H), 3.50 (s, 3H), 3.42 (s, 3H).

[0282] **Methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(methylsulfonyl)- α -L-glucofuranoside:** A solution of methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(phenylcarbonyl)- α -L-glucofuranoside (230mg, 0.92 mmol) and 50% sodium hydroxide (74 mg, 0.92 mmol) in methanol (5 mL) was stirred at room temperature for 30 minutes. The mixture was adsorbed on silica gel (2g) and passed through a short column (15% ethyl acetate in hexanes to 5% methanol in ethyl acetate) to afford a colorless oil which was employed directly in the next step, 140 mg, 0.72 mmol,

95% yield. The alcohol was dissolved in dichloromethane (5 mL) and pyridine (121 μ L, 1.03 mmol) was added at 0°C. Methanesulfonyl chloride (27 μ L, 0.88 mmol) was added and the resulting mixture was stirred at 0°C for 1 hour then at room temperature for 2 hours. The reaction mixture was washed with water and saturated aqueous sodium bicarbonate solution, dried over sodium sulfate, filtered and concentrated to give methyl 3,6-anhydro-2-*O*-methyl-5-*O*-(methylsulfonyl)- α -L-glucofuranoside as a colorless oil, 190 mg, 96% yield.

Example 65

[0283] 3,6-Anhydro-1,2-*O*-(1-methylethylidene)-5-*O*-(phenylcarbonyl)- α -L-gluco-

furanose: A mixture of 3,6-anhydro-5-*O*-(phenylcarbonyl)- α -L-glucofuranose (1.00g), 2,2-dimethoxy propane (0.63 mL), *p*-toluenesulfonic acid (20 mg) and benzene (10 mL) was heated at reflux for 3 hours. The reaction mixture was cooled then adsorbed on silica gel (10g) and purified by flash chromatography (silica gel, 5-35% ethyl acetate in hexanes) to give 3,6-anhydro-1,2-*O*-(1-methylethylidene)-5-*O*-(phenylcarbonyl)- α -L-glucofuranose as colorless oil, 0.85g, 74% yield. ^1H NMR (400MHz; CDCl_3): 8.08-8.06 (d, 2H), 7.59-7.56 (tr, 1H), 7.46-7.42 (m, 2H), 5.99-5.98 (d, 1H), 5.35-5.31 (tr, 1H), 5.10-5.08 (d, 1H), 4.66-4.65 (d, 1H), 4.61-4.60 (d, 1H), 4.20-4.16 (dd, 1H), 3.91-3.74 (tr, 1H), 1.50 (s, 3H), 1.34 (s, 3H).

[0284] 3,6-Anhydro-1,2-*O*-(1-methylethylidene)-5-*O*-(methylsulfonyl)- α -L-gluco-

furanose: A solution of 3,6-anhydro-1,2-*O*-(1-methylethylidene)-5-*O*-(phenylcarbonyl)- α -L-glucofuranose (850mg) and 50% sodium hydroxide (111 mg) in methanol (10mL) was stirred at room temperature for 30 minutes. The mixture was then adsorbed on silica gel (5g) and passed through a short column (15% ethyl acetate in hexanes to 5% methanol in ethyl acetate) and the alcohol intermediate, 390 mg, 70% yield, was used immediately in the next step. The alcohol was dissolved in dichloromethane (10 mL) and pyridine (0.32 mL) at 0°C. Methanesulfonyl chloride (0.12 mL) was added and the resulting mixture was stirred at 0°C for 1 hour then at room temperature for 2 hours. The reaction mixture was washed with water and saturated aqueous sodium bicarbonate solution, dried over anhydrous sodium sulfate, filtered and concentrated to give 3,6-anhydro-1,2-*O*-(1-methylethylidene)-5-*O*-(methylsulfonyl)- α -L-glucofuranose as a colorless oil, 485 mg, 90% yield, which was immediately employed in the next step.

Example 66

[0285] **(3*S*,8*aS*)-3-(Chloromethyl)hexahydro-1*H*-pyrrolo[2,1-*c*][1,4]oxazine:** (*S*)-(+)-Prolinol (6.00 g, 59.3 mmol) was added to epichlorohydrin (47 mL, 600 mmol) at 0°C. The solution was stirred at 40°C for 0.5 h and then concentrated *in vacuo*. The residual oil was cooled in an ice bath and concentrated sulfuric acid (18 mL) was added dropwise with stirring. The mixture was heated at 170-180°C for 1.5 h, poured into ice (300 mL) and then basified with sodium carbonate to pH~8. The mixture was partitioned with ethyl acetate/hexanes and filtered. The filtrate was separated and the aqueous portion was extracted twice with ethyl acetate. The combined organic portion was dried over sodium sulfate, filtered and concentrated *in vacuo* to afford oil that was purified by column chromatography (ethyl acetate for less polar product and then 30% methanol in ethyl acetate). (3*S*,8*aS*)-3-(Chloromethyl)hexahydro-1*H*-pyrrolo[2,1-*c*][1,4]oxazine (less polar product) (1.87 g, 10.7 mmol, 18% yield): ¹H NMR (400 MHz, CDCl₃): 4.06 (dd, 1H), 3.79-3.71 (m, 1H), 3.60-3.48 (m, 2H), 3.36 (dd, 1H), 3.15 (dd, 1H), 3.13-3.06 (m, 1H), 2.21-2.01 (m, 3H), 1.90-1.68 (m, 3H), 1.39-1.24 (m, 1H); MS (EI) for C₈H₁₄NOCl: 176 (MH⁺). (3*R*,8*aS*)-3-(Chloromethyl)hexahydro-1*H*-pyrrolo[2,1-*c*][1,4]oxazine (1.54 g, 8.77 mmol, 15% yield): ¹H NMR (400 MHz, CDCl₃): 3.94-3.77 (m, 4H), 3.55 (dd, 1H), 3.02-2.93 (m, 2H), 2.45 (dd, 1H), 2.29-2.15 (m, 2H), 1.88-1.64 (m, 3H), 1.49-1.38 (m, 1H); MS (EI) for C₈H₁₄NOCl: 176 (MH⁺).

[0286] Using the same or analogous synthetic techniques and/or substituting with alternative starting materials, the following were prepared:

[0287] **(3*R*,8*aR*)-3-(Chloromethyl)hexahydro-1*H*-pyrrolo[2,1-*c*][1,4]oxazine:** ¹H NMR (400 MHz, CDCl₃): 4.05 (dd, 1H), 3.79-3.70 (m, 1H), 3.61-3.48 (m, 2H), 3.35 (dd, 1H), 3.15 (dd, 1H), 3.13-3.07 (m, 1H), 2.21-2.01 (m, 3H), 1.89-1.67 (m, 3H), 1.39-1.25 (m, 1H); MS (EI) for C₈H₁₄NOCl: 176 (MH⁺).

[0288] **(3*S*,8*aR*)-3-(Chloromethyl)hexahydro-1*H*-pyrrolo[2,1-*c*][1,4]oxazine:** ¹H NMR (400 MHz, CDCl₃): 3.93-3.77 (m, 4H), 3.55 (dd, 1H), 3.02-2.93 (m, 2H), 2.45 (dd, 1H), 2.30-2.15 (m, 2H), 1.88-1.64 (m, 3H), 1.49-1.37 (m, 1H); MS (EI) for C₈H₁₄NOCl: 176 (MH⁺).

Example 67

[0289] **(3S,8aS)-Hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethyl acetate:** (3S,8aS)-3-(Chloromethyl)hexahydro-1H-pyrrolo[2,1-c][1,4]oxazine (2.30 g, 13.1 mmol) and potassium acetate (12.8 g, 131 mmol) were stirred in dimethylformamide (25 mL) at 140°C for 20 h. The mixture was partitioned between ethyl acetate and water. The organic portion was washed twice with water, then with brine, dried over sodium sulfate, filtered and concentrated *in vacuo* to afford (3S,8aS)-hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethyl acetate as a brown oil (2.53 g, 12.7 mmol, 97% yield). ¹H NMR (400 MHz, CDCl₃): 4.14–4.02 (m, 3H), 3.81–3.72 (m, 1H), 3.37–3.31 (m, 1H), 3.09 (dt, 1H), 3.00 (dd, 1H), 2.21–2.00 (m, 3H), 2.10 (s, 3H), 1.90–1.67 (m, 3H), 1.39–1.24 (m, 1H); MS (EI) for C₁₀H₁₇NO₃: 200 (MH⁺).

[0290] **(3S,8aS)-Hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethanol:** (3S,8aS)-Hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethyl acetate (2.36 g, 11.9 mmol) was treated with sodium methoxide (25 wt% solution in methanol; 2.7 mL) for 0.5 h. The mixture was cooled in an ice bath and a solution of 4M HCl in 1,4-dioxane (3 mL, 12.0 mmol) was added slowly. The mixture was stirred at room temperature for 5 minutes and then was concentrated *in vacuo* to afford a suspension which was diluted with dichloromethane, filtered and the filtrate was concentrated *in vacuo* to afford (3S,8aS)-hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethanol as a brown oil (1.93 g, >100% yield). ¹H NMR (400 MHz, CDCl₃): 4.05 (dd, 1H), 3.73–3.65 (m, 2H), 3.62–3.56 (m, 1H), 3.39–3.34 (m, 1H), 3.10 (dt, 1H), 3.00–2.95 (m, 1H), 2.24–1.98 (m, 4H), 1.97–1.70 (m, 3H), 1.44–1.28 (m, 1H); MS (EI) for C₈H₁₅NO₂: 158 (MH⁺).

[0291] **(3S,8aS)-hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethyl methanesulfonate:** (3S,8aS)-Hexahydro-1H-pyrrolo[2,1-c][1,4]oxazin-3-ylmethanol (1.00 g, 6.37 mmol) was dissolved in dichloromethane (10 mL) and triethylamine (2.4 mL, 17.3 mmol) was added at 0°C followed by dropwise addition of methanesulfonyl chloride (0.93 mL, 12.0 mmol). The solution was warmed to room temperature and stirred for 1.25 h and then was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and saturated sodium bicarbonate solution. The organic portion was washed with saturated sodium bicarbonate solution. The combined aqueous portion was extracted with ethyl acetate. The combined organic portion was washed with brine, dried over sodium sulfate, filtered and concentrated *in vacuo* to afford

(3*S*,8*aS*)-hexahydro-1*H*-pyrrolo[2,1-*c*][1,4]oxazin-3-ylmethyl methanesulfonate as an orange-brown oil (1.20 g, 5.1 mmol, 80% yield). MS (EI) for C₉H₁₇NO₄S: 236 (MH⁺).

Example 68

[0292] **Octahydro-2*H*-quinolizin-3-ylmethanol:** Ethyl octahydro-2*H*-quinolizine-3-carboxylate (2.35 g, 11.1 mmol) was added dropwise to a stirred suspension of lithium aluminum hydride (1 M solution in tetrahydrofuran, 33 mL, 33 mmol) in tetrahydrofuran (50 mL) at 0°C. The reaction was stirred at room temperature for 3 h. The mixture was cooled in an ice bath and ethyl acetate (6 mL) was added slowly, followed by water (1.25 mL), 15% aqueous sodium hydroxide solution (5 mL) and water (1.25 mL). The mixture was filtered through a pad of celite and washed with ether. The filtrate was concentrated *in vacuo* and dried rigorously to afford octahydro-2*H*-quinolizin-3-ylmethanol as a yellow oil (1.66 g, 9.82 mmol, 88% yield). MS (EI) for C₁₀H₁₉NO: 170 (MH⁺).

[0293] **Octahydro-2*H*-quinolizin-3-ylmethyl methanesulfonate:** Octahydro-2*H*-quinolizin-3-ylmethanol (600 mg, 3.55 mmol) was dissolved in dichloromethane (8 mL) and triethylamine (1.5 mL, 10.8 mmol) was added at 0°C followed by dropwise addition of methanesulfonyl chloride (0.56 mL, 7.16 mmol). The solution was warmed to room temperature and stirred for 1.25 h and then was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and saturated sodium bicarbonate solution. The aqueous portion was extracted with ethyl acetate. The combined organic portion was washed with brine, dried over sodium sulfate, filtered and concentrated *in vacuo* to afford octahydro-2*H*-quinolizin-3-ylmethyl methanesulfonate as an orange oil (796 mg, 3.22 mmol, 91% yield). MS (EI) for C₁₁H₂₁NO₃S: 248 (MH⁺).

Example 69

[0294] **(3*S*,8*aS*)-3-(Hydroxymethyl)hexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one:** A solution of methyl 1-[(2*S*)-3-hydroxy-2-([[(phenylmethyl)oxy]carbonyl]amino)propyl]-L-prolinate (3.50 g, 10.4 mmol) in methanol was added to 5% palladium on carbon (50 wt.% in water) in methanol and treated with hydrogen at 40 psi for 1 h. The mixture was filtered and the filtrate was brought to reflux briefly and then cooled and concentrated *in vacuo* to afford (3*S*,8*aS*)-3-(hydroxymethyl)hexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one as a colorless solid (1.50 g, 8.83 mmol, 85% yield). ¹H NMR (400 MHz, CDCl₃): 7.28-7.22 (m, 1H), 3.83-3.75

(m, 1H), 3.69 (dd, 1H), 3.56 (dd, 1H), 3.31 (t, 1H), 3.08 (dd, 1H), 2.92 (dt, 1H), 2.76-2.70 (m, 1H), 2.66 (dd, 1H), 2.28-2.16 (m, 1H), 2.02-1.73 (m, 3H); MS (EI) for $C_8H_{14}N_2O_2$: 171 (MH^+).

[0295] (3*S*,8*aS*)-3-(((1,1-Dimethylethyl)(dimethyl)silyl)oxy)methyl)hexahydro-pyrrolo[1,2-*a*]pyrazin-1(2*H*)-one: To a solution of (3*S*,8*aS*)-3-(hydroxymethyl)hexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one (1.49 g, 8.82 mmol) in dimethylformamide (20 mL) was added triethylamine (2.45 mL, 17.6 mmol) and 4-dimethylaminopyridine (90 mg, 0.882 mmol). The solution was cooled in an ice bath and *tert*-butyldimethylsilyl chloride (2.66 g, 17.6 mmol) was added. The mixture was warmed to room temperature and stirred for 14 h. The mixture was concentrated *in vacuo* and the residue was partitioned between ethyl acetate and water. The aqueous portion was extracted twice with ethyl acetate. The combined organic portion was dried over sodium sulfate, filtered and concentrated *in vacuo* to afford a pale brown solid which was triturated with ethyl acetate to afford (3*S*,8*aS*)-3-(((1,1-dimethylethyl)(dimethyl)silyl)oxy)methyl)hexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one as an off-white solid (1.74 g, 5.84 mmol, 66% yield). 1H NMR (400 MHz, $CDCl_3$): 6.09-5.90 (m, 1H), 3.86-3.76 (m, 1H), 3.63 (dd, 1H), 3.44 (dd, 1H), 3.25 (t, 1H), 3.10 (ddd, 1H), 2.98-2.90 (m, 1H), 2.68-2.60 (m, 1H), 2.52 (dd, 1H), 2.28-2.18 (m, 1H), 2.06-1.95 (m, 1H), 1.93-1.74 (m, 2H), 0.90 (s, 9H), 0.07 (s, 6H); MS (EI) for $C_{14}H_{28}N_2O_2Si$: 285 (MH^+).

[0296] (3*S*,8*aS*)-3-(((1,1-Dimethylethyl)(dimethyl)silyl)oxy)methyl)-2-methylhexahydro pyrrolo[1,2-*a*]pyrazin-1(2*H*)-one: (3*S*,8*aS*)-3-(((1,1-Dimethylethyl)(dimethyl)silyl)oxy)methyl)hexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one (1.51 g, 5.32 mmol) in dimethylformamide (8 mL) was added to an ice-cooled suspension of sodium hydride (60 wt.% dispersion in oil; 213 mg, 5.32 mmol) in dimethylformamide (8 mL). The mixture was stirred at 0°C for 0.25 h and then iodomethane (0.332 mL, 5.32 mmol) was added dropwise. The mixture was stirred at room temperature for 0.5 h and then was stirred at 70°C for 2 h. The mixture was concentrated *in vacuo* and the residue was partitioned between ethyl acetate and water. The aqueous portion was extracted with ethyl acetate. The combined organic portion was dried over sodium sulfate, filtered and concentrated *in vacuo* to afford (3*S*,8*aS*)-3-(((1,1-dimethylethyl)(dimethyl)silyl)oxy)methyl)-2-methylhexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one as a yellow oil (1.552 g, 5.21 mmol) which was dissolved in tetrahydrofuran (20 mL) and treated with tetrabutylammonium fluoride (1.0M solution in tetrahydrofuran; 10.4 mL, 10.4 mmol) for 2 h at room temperature. The mixture was concentrated *in vacuo* and purified by

column chromatography (10% methanol in dichloromethane) to afford (3*S*,8*aS*)-3-(hydroxymethyl)-2-methylhexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one as a yellow oil (496mg, 2.70mmol, 51% yield from (3*S*,8*aS*)-3-(((1,1-dimethylethyl)(dimethyl)silyloxy)methyl)hexahydropyrrolo[1,2-*a*]pyrazin-1(2*H*)-one). ¹H NMR (400 MHz, CDCl₃): 3.98-3.93 (m, 1H), 3.86 (dd, 1H), 3.61-3.55 (m, 1H), 3.29-3.25 (m, 1H), 3.09-3.03 (m, 1H), 3.03-2.97 (m, 1H), 3.02 (s, 3H), 2.93 (dd, 1H), 2.87-2.79 (m, 1H), 2.32-2.21 (m, 1H), 2.00-1.86 (m, 2H), 1.83-1.64 (m, 1H); MS (EI) for C₉H₁₆N₂O₂: 185 (MH⁺).

Example 70

[0297] **1,2-Dideoxy-1-[(2*S*)-2-(methoxycarbonyl)-1-pyrrolidinyl]-2-[(phenylmethoxy)carbonyl]amino]-D-glycero-hexitol:** To a solution of 2-deoxy-2-[(phenylmethoxy)carbonyl]amino]-D-glycero-hexopyranose (5.0 g, 0.016 mol) in methanol (500 mL) was added L-proline methyl ester hydrochloride (2.8 g, 0.022 mol) and sodium cyanoborohydride (3.4 g, 0.054 mol). The solution was heated to 64 °C for 14 h. After cooling to room temperature, the reaction mixture was concentrated *in vacuo* to afford 1,2-dideoxy-1-[(2*S*)-2-(methoxycarbonyl)-1-pyrrolidinyl]-2-[(phenylmethoxy)carbonyl]amino]-D-glycero-hexitol (6.81 g, 100%) as a clear and colorless oil. MS (EI) for C₂₀H₃₁N₂O₈: 427 (MH⁺).

Example 71

[0298] **Methyl 1-[(2*S*)-3-hydroxy-2-(((phenylmethyl)oxy)carbonyl)amino)propyl]-L-prolinate:** 1,2-dideoxy-1-[(2*S*)-2-(methoxycarbonyl)-1-pyrrolidinyl]-2-[(phenylmethoxy)carbonyl]amino]-D-glycero-hexitol (6.81 g, 0.016 mol) was taken into water (100 mL) and the resulting solution was cooled to 0°C. Sodium periodate (14.8 g, 0.069 mol) dissolved in water was added dropwise and the resulting mixture was stirred at 0°C for 2 h. The reaction mixture was partitioned with dichloromethane (3x100 mL), dried over anhydrous magnesium sulfate, filtered and concentrated *in vacuo*. The residue was taken up in methanol (200 mL) and the resulting solution was cooled to 0°C. Sodium borohydride (1.98 g, 0.052 mol) was added and the reaction mixture was stirred for 1 h at 0°C. The reaction mixture was concentrated *in vacuo* and partitioned with dichloromethane and saturated aqueous ammonium chloride. The organic layer was dried over anhydrous magnesium sulfate, filtered and concentrated *in vacuo*. The resulting crude product was purified by column chromatography (5% methanol in dichloromethane) to yield methyl 1-[(2*S*)-3-hydroxy-2-

([[(phenylmethyl)oxy]carbonyl]amino)propyl]-L-prolinate (4.9 g, 92%) as a white solid. MS (EI) for $C_{17}H_{25}N_2O_5$: 337 (MH^+).

[0299] Methyl 1-[(2S)-3-[(methylsulfonyl)oxy]-2-([[(phenylmethyl)oxy]carbonyl]amino)propyl]-L-prolinate: Methyl 1-[(2S)-3-hydroxy-2-([[(phenylmethyl)oxy]carbonyl]amino)propyl]-L-prolinate (200 mg, 0.594 mmol) was dissolved in dichloromethane (5 mL) followed by the addition of 4-(dimethylamino)pyridine (3.6 mg, 0.039 mmol) and triethylamine (0.125 mL, 0.891 mmol) and the resulting mixture was cooled to 0 °C. Methanesulfonyl chloride (0.060 mL, 0.773 mmol) was added dropwise and the reaction mixture was stirred for 1 h at 0°C. The mixture was partitioned between dichloromethane and saturated aqueous sodium bicarbonate. The organic layer was dried over anhydrous magnesium sulfate, filtered and concentrated *in vacuo* to afford methyl 1-[(2S)-3-[(methylsulfonyl)oxy]-2-([[(phenylmethyl)oxy]carbonyl]amino)propyl]-L-prolinate (246 mg, 100%) as a clear and colorless oil. MS (EI) for $C_{18}H_{27}N_2O_7S$: 415 (MH^+).

Example 72

[0300] 1,1-Dimethylethyl (3aR,6aS)-5-(hydroxymethyl)hexahydrocyclopenta[c]pyrrole-2(1H)-carboxylate: Under a nitrogen atmosphere, borane tetrahydrofuran complex (1M in THF, 42 mL, 41.9 mmol) was diluted with tetrahydrofuran (42 mL) and cooled with an ice bath. Neat 2,3-dimethylbut-2-ene (5.0 mL, 41.9 mmol) was added in portions over 0.25 h and the solution was stirred at 0°C for 3 h. A solution of 1,1-dimethylethyl (3aR,6aS)-5-methylidenehexahydrocyclopenta[c]pyrrole-2(1H)-carboxylate (1.98 g, 8.88 mmol) in tetrahydrofuran (10 mL) was added slowly, and the solution was warmed to room temperature and stirred 12 h. After cooling to 0°C, 10% aqueous sodium hydroxide (17 mL, 41.7 mmol) was added slowly, followed by 30% aqueous hydrogen peroxide (13 mL, 128 mmol) and the solution was warmed to room temperature. The solvent was removed *in vacuo* and the solution was partitioned between water and diethyl ether. The layers were separated and the aqueous layer was further extracted (3 x 50 mL diethyl ether). The combined organic layers were dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to provide 2.04 (95%) of 1,1-dimethylethyl (3aR,6aS)-5-(hydroxymethyl)hexahydrocyclopenta[c]pyrrole-2(1H)-carboxylate, which was used without purification. 1H NMR (400 MHz, $CDCl_3$): 8.50 (broad s, 1H), 3.66-3.46 (m, 3H), 3.20-3.00 (m, 2H), 2.70-2.59 (m, 2H), 2.37-2.18 (m, 1H), 2.04 (m, 1H), 1.84 (broad s, 1H), 1.70-1.55 (m, 1H), 1.46 (s, 9H), 1.17 (m, 1H), 0.93 (m, 1H).

[0301] 1,1-Dimethylethyl (3aR,6aS)-5-[[[(methanesulfonyl)oxy]methyl]hexahydrocyclopenta [c]pyrrole-2(1H)-carboxylate: Methanesulfonyl chloride (0.2 mL, 2.48 mmol), was added dropwise to a solution of 1,1-dimethylethyl (3aR,6aS)-5-(hydroxymethyl)hexahydrocyclopenta[c] pyrrole-2(1H)-carboxylate (0.40 g, 1.65 mmol) and triethylamine (0.69 mL, 4.95 mmol) in 20 mL dichloromethane at 0°C and the reaction mixture was stirred for 1 h at room temperature. The solvent was evaporated, the resulting crude mixture was diluted with 100 mL ethyl acetate and washed with water (30 mL), 1M aqueous sodium hydroxide, brine, 1M aqueous hydrochloric acid and brine again. The organic layer was dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. The resulting 1,1-dimethylethyl (3aR,6aS)-5-[[[(methanesulfonyl)oxy]methyl]hexahydrocyclopenta[c]pyrrole-2(1H)-carboxylate was used without further purification. MS (EI) for C₁₄H₂₅NO₅S: 320 (MH⁺), 264 (M-tBu).

Example 73

[0302] 1,1-Dimethylethyl (3aR,6aS)-5-(hydroxy)-hexahydrocyclopenta[c] pyrrole-2(1H)-carboxylate: Sodium borohydride (0.15 g, 4.00 mmol), was added to a solution of 1,1-dimethylethyl (3aR,6aS)-5-oxo-hexahydrocyclopenta[c] pyrrole-2(1H)-carboxylate (0.45 g, 2.00 mmol) in 10 mL methanol at 0°C and the reaction mixture was stirred for 1 h at this temperature. The solvent was evaporated, the crude mixture was diluted with 100 mL ethyl acetate and washed with water (30 mL), 1M aqueous hydrochloric acid and brine. The organic layer was dried over anhydrous sodium sulfate, filtered and concentrated to give 1,1-dimethylethyl (3aR,6aS)-5-(hydroxy)-hexahydrocyclopenta[c] pyrrole-2(1H)-carboxylate (0.44 g, 98%). ¹H NMR (400 MHz, d₆-DMSO): 4.08 (m, 1H), 3.40 (m, 2H), 3.30 (m, 2H), 2.50 (m, 2H), 1.98 (m, 2H), 1.40 (s, 9H), 1.30 (m, 2H). MS (EI) for C₁₂H₂₁NO₃: 228 (MH⁺).

[0303] 1,1-Dimethylethyl (3aR,6aS)-5-[[[(methanesulfonyl)oxy]]hexahydrocyclopenta[c]pyrrole-2(1H)-carboxylate: Methanesulfonyl chloride (0.18 mL, 2.33 mmol), was added dropwise to a solution of 1,1-dimethylethyl (3aR,6aS)-5-(hydroxy)-hexahydrocyclopenta[c] pyrrole-2(1H)-carboxylate (0.44 g, 1.94 mmol) and triethylamine (0.81 mL, 5.81 mmol) in 10 mL dichloromethane at 0°C and the reaction mixture was stirred for 1 h at room temperature. The solvent was evaporated, the resulting crude mixture was diluted with 100 mL ethyl acetate and washed with water (30 mL), brine, 1M aqueous hydrochloric acid and brine again. The organic layer was dried over anhydrous sodium

sulfate, filtered and concentrated. The resulting crude 1,1-dimethylethyl (3a*R*,6a*S*)-5-[[[(methylsulfonyl)oxy]]hexahydrocyclopenta[*c*]pyrrole-2(1*H*)-carboxylate was used without further purification. MS (EI) for C₁₃H₂₃NO₅S: 306 (MH⁺).

Example 74

[0304] **3-(Chloromethyl)hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazine:** A solution of (3*R*)-morpholin-3-ylmethanol (4.21 g, 36.0 mmol) in 2-(chloromethyl)oxirane (28.2 mL, 0.360 mol) was heated to 40°C for 3 h and then the solution was concentrated *in vacuo*. The intermediate was cooled in an ice bath and treated with 30.0 mL of concentrated sulfuric acid. The mixture was heated to 170°C for 2 h and then allowed to cool to room temperature. The mixture was poured into ice-water and solid sodium bicarbonate was carefully added until the solution was basic. 10% methanol in ethyl acetate was added and the biphasic mixture was filtered. The layers were separated and the aqueous layer was extracted (3 x 100 mL 10% methanol in ethyl acetate). The combined organic layers were dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo*. Column chromatography (SiO₂, 2:5 hexanes:ethyl acetate) provided 3-(chloromethyl)hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazine 2.44g (35%) as two separated diastereomers. (3*R*,9a*S*)-3-(chloromethyl)hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazine: (0.886 g, 13% yield): ¹H NMR (400 MHz, CDCl₃): 3.91 (m, 3H), 3.82 (m, 1H), 3.68 (dt, 1H), 3.61 (dd, 1H), 3.47 (dd, 1H), 3.35 (t, 1H), 3.19 (t, 1H), 2.80 (d, 1H), 2.54 (m, 2H), 2.40 (m, 2H); MS (EI) for C₈H₁₄NO₂Cl: 192 (MH⁺). (3*S*,9a*S*)-3-(chloromethyl)hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazine: (1.55 g, 22% yield): ¹H NMR (400 MHz, CDCl₃): 3.85 (m, 2H), 3.73 (m, 3H), 3.50 (m, 2H), 3.29 (t, 1H), 3.18 (t, 1H), 2.85 (dd, 1H), 2.64 (dd, 1H), 2.40 (m, 2H), 2.17 (t, 1H); MS (EI) for C₈H₁₄NO₂Cl: 192 (MH⁺).

[0305] **Hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl acetate:** A suspension of (3*R*,9a*S*)-3-(chloromethyl)hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazine (1.97 g, 10.3 mmol) and potassium acetate (10.1 g, 102 mmol) in DMF (20.0 mL) was stirred at 140°C for 16 h, and then at 150°C for another 12 h. The reaction mixture was partitioned between water (250 mL) and ethyl acetate (250 mL), the organic layer was washed with 5% lithium chloride (2 x 100 mL) and brine (100 mL) then dried over anhydrous sodium sulfate and concentrated *in vacuo*. Column chromatography (SiO₂, 1:1 hexane:ethyl acetate, then 100% ethyl acetate) afforded 0.92 g (42%) of hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl acetate as a yellow oil. Distinct diastereomers as described above were converted in this step to give:

(3*R*,9*aS*)-hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl acetate: ¹H NMR (400 MHz, CDCl₃): 4.18 (dd, 1H), 4.00 (m, 1H), 3.80 (dd, 1H), 3.68 (dt, 1H), 3.60 (dd, 1H), 3.46 (m, 2H), 3.22 (t, 1H), 2.64 (dd, 1H), 2.53 (m, 2H), 2.43-2.35 (m, 2H), 2.10 (s, 3H), and (3*S*,9*aS*)-hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl acetate: ¹H NMR (400 MHz, CDCl₃): 4.09 (d, 2H), 3.90-3.82 (m, 2H), 3.75-3.64 (m, 3H), 3.27 (t, 1H), 3.18 (t, 1H), 2.69 (dd, 1H), 2.63 (m, 1H), 2.46-2.33 (m, 2H), 2.16 (t, 1H), 2.10 (s, 3H).

[0306] **(3*R*,9*aS*)-Hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl methanesulfonate:** To a solution of (3*R*,9*aS*)-hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl acetate (0.922 g, 4.28 mmol) in methanol (14.0 mL) was added 1.03 mL (4.50 mmol) of sodium methoxide (25% wt. in methanol) dropwise at room temperature. After 5 min., 1.6 mL (6.43 mmol) of 4.0M hydrogen chloride in dioxane was added and a pink precipitate formed. The solution was concentrated *in vacuo* and the pink solid was taken up in 30.0 mL dichloromethane. This slurry was cooled in an ice bath and triethylamine (3.0 mL, 21.5 mmol) was added, followed by methanesulfonyl chloride (0.37 mL, 4.71 mmol). The resultant yellow solution was stirred for 30 minutes at room temperature. The mixture was then partitioned between dichloromethane and saturated aqueous sodium bicarbonate then the aqueous layer was extracted (3 x 50 mL dichloromethane). The combined organic layers were dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to provide crude (3*R*,9*aS*)-hexahydro-1*H*-[1,4]oxazino[3,4-*c*][1,4]oxazin-3-ylmethyl methanesulfonate which was taken on to the following reaction without purification.

Example 75

[0307] **(8*aR*)-6-(Chloromethyl)tetrahydro-1*H*-[1,3]thiazolo[4,3-*c*][1,4]oxazine:** A solution of (4*R*)-1,3-thiazolidin-4-ylmethanol (0.300 g, 2.52 mmol) in 2-(chloromethyl)oxirane (2.0 mL, 25.5 mmol) was heated under nitrogen to 40°C for 12 h. The solution was then cooled to room temperature and 2-(chloromethyl)oxirane was removed *in vacuo*. The crude intermediate was cooled in ice, and was taken up in 2.0 mL of concentrated sulfuric acid. The resulting mixture was heated to 200°C for 0.5 h then poured carefully onto wet ice, which was allowed to melt. The aqueous solution was carefully made basic using solid sodium bicarbonate and the resulting mixture was filtered using water and 10% methanol in ethyl acetate as eluent. The layers were separated and the aqueous layer was extracted with 10% methanol in ethyl acetate. The combined organic layers were dried over

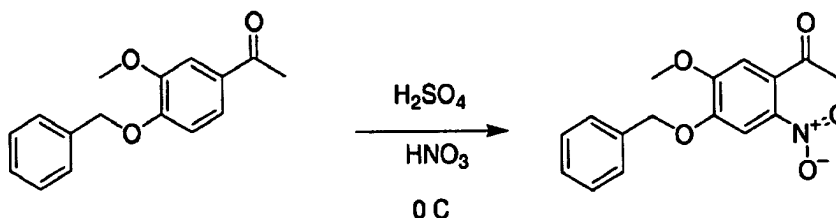
anhydrous sodium sulfate, filtered, and concentrated *in vacuo* to give 11.6 mg (2.4% yield) of crude (8a*R*)-6-(chloromethyl)tetrahydro-1*H*-[1,3]thiazolo[4,3-*c*][1,4]oxazine as a mixture of diastereomers which was directly taken on to the next step.

Example 76

[0308] **1,1-Dimethylethyl (3-*endo*)-3-{2-[(methylsulfonyl)oxy]ethyl}-8-azabicyclo[3.2.1]octane-8-carboxylate:** To a solution of 1,1-dimethylethyl (3-*endo*)-3-(2-hydroxyethyl)-8-azabicyclo[3.2.1]octane-8-carboxylate (30.3 mg, 1.19 mmol) in dichloromethane (4.0 mL), was added triethylamine (0.5 mL, 3.56 mmol) and the solution was cooled to 0°C under nitrogen. Methanesulfonyl chloride (0.11 mL, 1.42 mmol) was added slowly and mixture was allowed to warm to room temperature and stirred for 1h. The reaction mixture was partitioned between dichloromethane and water. The aqueous phase was extracted with dichloromethane (2 x 100 mL). The combined organic layers were dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to provide 35.1 mg (89%) of 1,1-dimethylethyl (3-*endo*)-3-{2-[(methylsulfonyl)oxy]ethyl}-8-azabicyclo[3.2.1]octane-8-carboxylate, which was carried forward for alkylation without purification.

More Quinoline and Quinazoline Syntheses

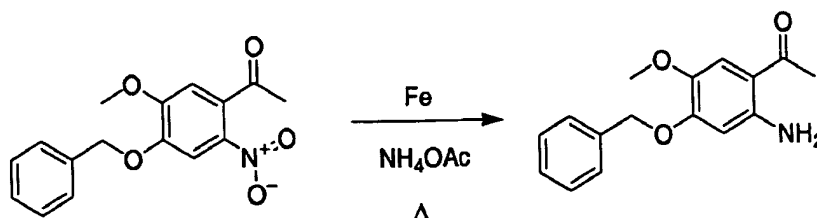
Example 77



[0309] **Synthesis of 1-(4-Benzyloxy-5-methoxy-2-nitro-phenyl)-ethanone.** 1-(4-Benzyloxy-3-methoxy-phenyl)-ethanone (200 mmol, 51.3 g) dissolved in DCM (750ml) and the mixture cooled to 0° C. Nitric acid (90%, 300 mmol, 14 ml) was added dropwise to the cooled solution over 20 minutes. Sulfuric acid (96.2%, 300 mmol, 8.75 ml) was then added dropwise over 40 minutes at 0° C. Additional nitric acid (200 mmol, 9.4 ml) was added dropwise over 20 minutes. The reaction mixture was diluted with water (300 ml) and wash with water (3 X 200 ml), Sat. NaHCO₃ (4 X 200 ml, or until neutral). The organic layer was dried over Na₂SO₄ and concentrated. The crude mixture was recrystallized with DMF to

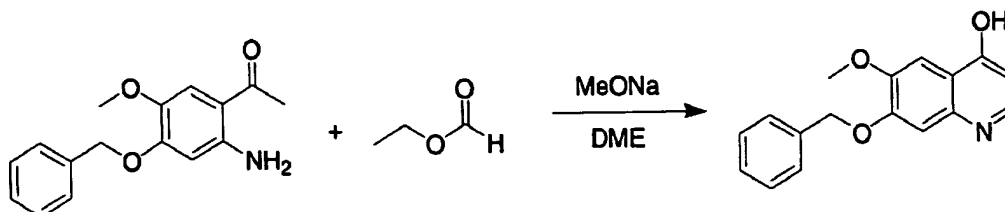
give 22.5 g of the nitro product. The DMF layer was concentrated and recrystallized with ethyl acetate to give additional 8.75g of the product. The ethyl acetate layer was concentrated and purified on silica column using 20% EtOAc/hexanes to gave another 4.75 g of the product. Total yield is 36 g, (~60%). ^1H NMR (CDCl_3): 7.647 (1H, s), 7.446-7.333 (5H, m), 6.745 (1H, s), 5.210 (2H, s), 3.968 (3H, s), 2.487 (3H, s).

Example 78



[0310] Synthesis of 1-(2-Amino-4-benzyloxy-5-methoxy-phenyl)-ethanone. A Mixture of iron powder (477 mmol, 27 g), ammonium acetate (500 mmol, 31.g), 1-(4-Benzyloxy-5-methoxy-2-nitro-phenyl)-ethanone (120 mmol, 36 g), toluene (500 ml) and water (500 ml) was refluxed overnight, or until completion. The mixture was filtered through celite and washed with EtOAc. The organic layer was washed with water and Sat. NaCl, dried over Na_2SO_4 , and concentrated to afford the product, 90%. ^1H NMR (CDCl_3): 7.408-7.298 (5H, m), 7.130 (1H, s), 6.155 (2H, br), 6.104 (1H, s), 5.134 (2H, s), 3.834 (3H, s), 2.507 (3H, s). LC/MS ($M+1 = 272$).

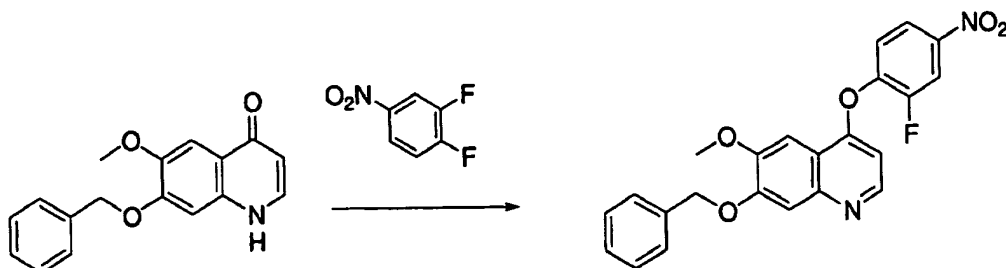
Example 79



[0311] Synthesis of 7-Benzyloxy-6-methoxy-quinolin-4-ol. To a solution of 1-(2-Amino-4-benzyloxy-5-methoxy-phenyl)-ethanone (108 mmol, 29.3 g) in DME (700 ml) was added sodium methoxide (432 mmol, 23.35 g). The mixture was stirred for 30 minutes. Ethyl formate (540 mmol, 44 ml) was added and the mixture was stirred overnight. (Additional sodium methoxide may be needed if reaction is not complete as monitored by LC/MS.) After the reaction was completion, the mixture was diluted with water (40 ml) and acidified to neutral with 1M HCl. The precipitate was filtered and washed with water, dried *in vacuo* to

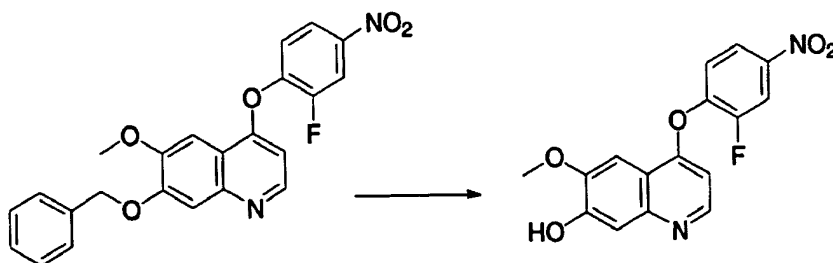
afford 22g (72%) of 7-benzyloxy-6-methoxy-quinolin-4-ol. ^1H NMR (CDCl_3): 10.7 (1H, br), 7.703 (1H, s), 7.493-7.461 (1H, t), 7.431-7.413 (2H, br d), 7.372-7.333 (2H, t), 7.296-7.283 (1H, d), 6.839 (1H, s), 6.212-6.193 (1H, d), 5.212 (2H, s), 3.965 (3H, s). LC/MS ($\text{M}+1 = 282$).

Example 80



[0312] **7-Benzyloxy-4-(2-fluoro-4-nitro-phenoxy)-6-methoxy-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 7-Benzyloxy-6-methoxy-1H-quinolin-4-one (12.2 g, 43.3 mmol, 1.0 eq.), acetonitrile (150ml), DMF (150ml) and cesium carbonate (28.2 g, 86.5 mmol, 2.0 eq). The mixture was stirred at room temperature for 30 minutes at which time 1,2-difluoro-4-nitro-benzene (7.57 g, 47.6 mmol, 1.1 eq) was added over a 10 minute period. After 2 hours the reaction was complete at which time 75% of the MeCN and DMF was removed and the resulting solution was poured over into ice water. The solid was filtered and dried and further columned with a biotage system. The eluent was 1:3 ethyl acetate/hexane. Removal of the solvent afforded 7-Benzyloxy-4-(2-fluoro-4-nitro-phenoxy)-6-methoxy-quinoline as a pale green solid (7.4 g, 41% yield). ^1H NMR (400 MHz, CDCl_3): 8.53 (d, 1H), 8.42 (dd, 1H), 8.16 (m, 1H), 7.5 (m, 8H), 6.76 (d, 1H), 5.31 (s, 2H), 3.92 (s, 3H); MS (EI) for $\text{C}_{23}\text{H}_{27}\text{FN}_2\text{O}_5$: 421 (MH^+).

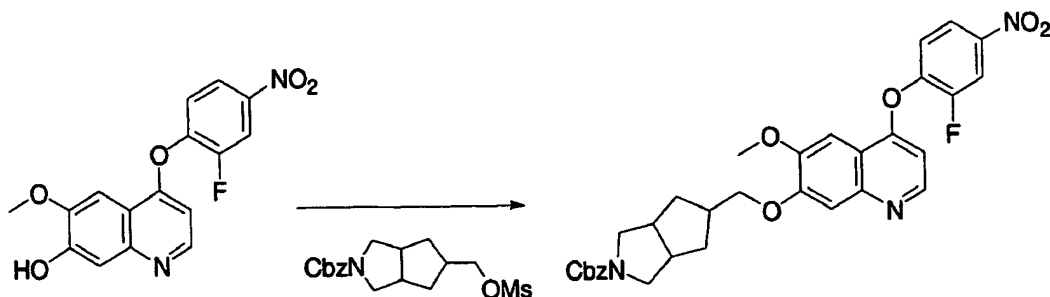
Example 81



[0313] **4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-quinolin-7-ol.** To a round bottom flask equipped with a magnetic stir bar was added 7-Benzyloxy-4-(2-fluoro-4-nitro-phenoxy)-6-

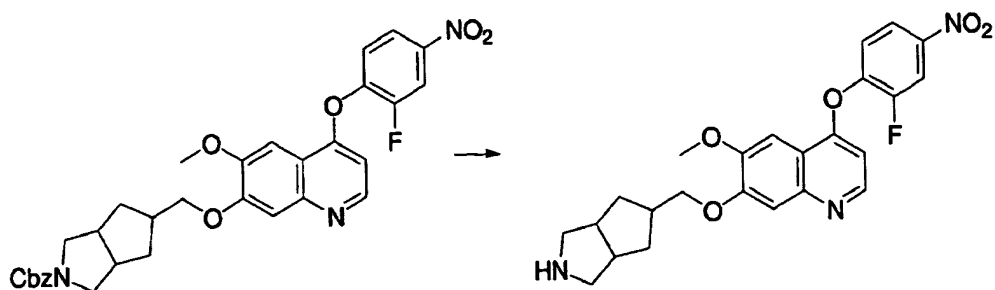
methoxy-quinoline (2.9 g, 6.9 mmol, 1.0eq) and 33% HBr in acetic acid (30 ml). The mixture was stirred at room temperature for 3 hours and diluted with ether to give a pale white solid. The solid was filtered, washed with ether and dried to yield 4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-quinolin-7-ol as a pale white solid (2.74 g, 97.5% yield). ^1H NMR (400 MHz, CDCl_3): 11.89 (bs, 1H), 8.87 (d, 1H), 8.57 (d, 1H), 8.30 (d, 1H), 7.89 (m, 1H), 7.73 (s, 1H), 7.55 (s, 1H), 4.03 (s, 3H); MS (EI) for $\text{C}_{16}\text{H}_{11}\text{FN}_2\text{O}_5$: 421 ($\text{M}+\text{H}^+$).

Example 82



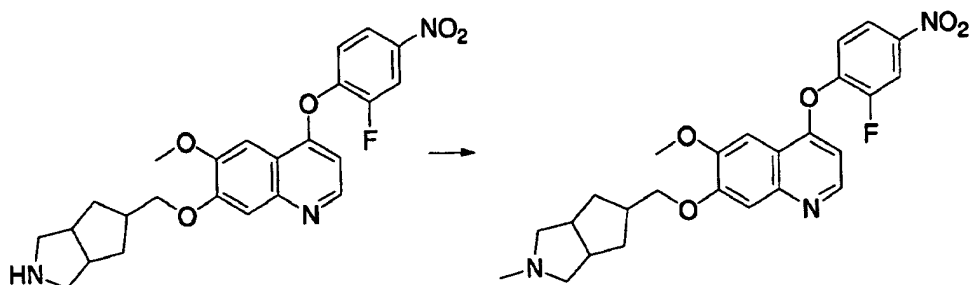
[0314] **5-[4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-quinolin-7-yloxymethyl]-hexahydro-cyclopenta[c]pyrrole-2-carboxylic acid benzyl ester.** To a round bottom flask equipped with a magnetic stir bar was added 4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-quinolin-7-ol (2.74 g, 6.7 mmol, 1.0 eq.), DMA (30ml) and cesium carbonate (6.6 g, 20.2 mmol, 3.0 eq). The mixture was stirred at room temperature for 30 minutes at which time 5-methanesulfonyloxymethyl-hexahydro-cyclopenta[c]pyrrole-2-carboxylic acid benzyl ester (2.6 g, 7.3 mmol, 1.1 eq) was added. The reaction was heated to 75°C and allowed to stir overnight. After allowing the reaction to cool to room temperature the reaction was poured into water. The solid was filtered and was then dissolved in EtOAc and washed 2X water, 1X brine and dried over NaSO_4 . The solvent was removed to yield 5-[4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-quinolin-7-yloxymethyl]-hexahydro-cyclopenta[c]pyrrole-2-carboxylic acid benzyl ester as a cream solid (3.7 g, 94% yield). ^1H NMR (400 MHz, CDCl_3): 8.55 (d, 1H), 8.15 (d, 1H), 8.09 (d, 1H), 7.32 (m, 8H), 6.52 (d, 1H), 5.11 (d, 2H), 4.13 (d, 2H), 3.95 (s, 3H), 3.57 (m, 2H), 3.43 (m, 2H), 2.93 (m, 3H), 2.16 (m, 2H), 1.39 (m, 2H); MS (EI) for $\text{C}_{32}\text{H}_{30}\text{FN}_3\text{O}_7$: 588 ($\text{M}+\text{H}^+$).

Example 83



[0315] **4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-7-(octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 5-[4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-quinolin-7-yloxymethyl]-hexahydrocyclopenta[c]pyrrole-2-carboxylic acid benzyl ester (2.5 g, 4.1 mmol, 1.0eq), 33% HBr in acetic acid (5 ml) and acetic acid (5 ml). The mixture was stirred at room temperature for 1 hour and diluted with EtOAc to give a pale orange solid. The solid was filtered, washed with EtOAc and dried, giving 4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-7-(octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinoline (2.1 g, 95% yield). ^1H NMR (400 MHz, CDCl_3): 8.83 (d, 1H), 8.32 (m, 2H), 8.02 (s, 1H), 7.76 (t, 1H), 7.65 (s, 1H), 6.89 (d, 1H), 5.3 (d, 2H), 4.11 (m, 3H), 3.26 (m, 4H), 2.95 (m, 2H), 2.68 (m, 3H), 2.36 (m, 2H), 1.68 (m, 2H); MS (EI) for $\text{C}_{24}\text{H}_{24}\text{FN}_3\text{O}_5$: 454 ($\text{M}+\text{H}^+$).

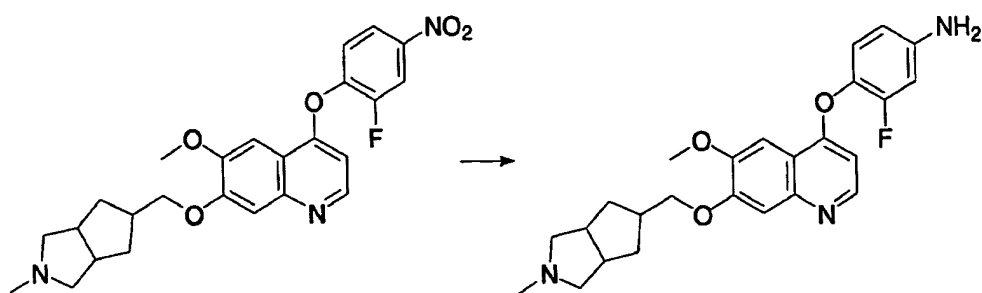
Example 84



[0316] **4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-7-(2-methyl-octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-7-(octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinoline (2.1 g, 3.9 mmol, 1.0 eq.) and acetonitrile/water 1:1 (5ml, 5ml). The reaction mixture was then cooled to 0°C and 37% solution of formaldehyde in water was added (0.2 g, 7.8 mmol, 2.0 eq). While keeping the temperature at 0°C $\text{Na}(\text{OAc})_3\text{BH}$ was added (4.4g, 20.7 mmol, 3.0 eq). After 1 hour the pH was adjusted to 10 and the aqueous

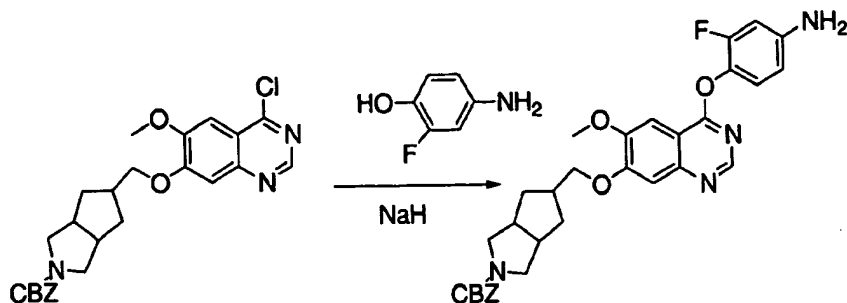
was extracted 2 x DCM (100 ml). Removal of the DCM resulted in a white solid. The compound was further purified with a biotage system using an eluent EtOAc and 5% MeOH, affording 4-(2-Fluoro-4-nitro-phenoxy)-6-methoxy-7-(2-methyl-octahydrocyclopenta[c]pyrrol-5-ylmethoxy)-quinoline (0.9 g, 50% yield). ^1H NMR (400 MHz, CDCl_3): 8.57 (d, 1H), 8.14 (dd, 1H), 8.12 (dd, 1H), 7.41 (s, 2H), 7.34 (t, 1H), 6.54 (d, 1H), 4.19 (d, 2H), 4.01 (s, 3H), 2.61 (m, 4H), 2.43 (m, 1H), 2.33 (s, 3H), 2.11 (m, 4H), 1.32 (m, 2H); MS (EI) for $\text{C}_{25}\text{H}_{26}\text{FN}_3\text{O}_5$: 468 ($\text{M}+\text{H}^+$).

Example 85



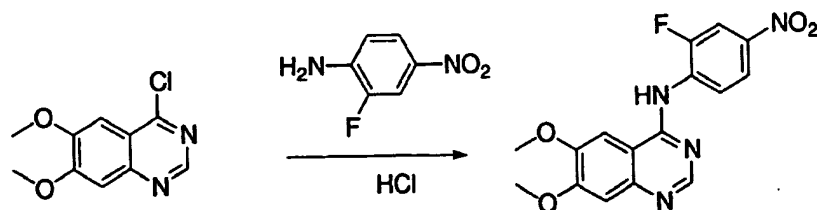
[0317] **3-Fluoro-4-[6-methoxy-7-(2-methyl-octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinolin-4-yloxy]-phenylamine.** To a par hydrogenation reaction vessel was added 4-(2-fluoro-4-nitro-phenoxy)-6-methoxy-7-(2-methyl-octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinoline (0.800 g, 1.6 mmol, 1.0 eq.), DMF (50 ml), EtoAc (50ml), MeOH (50ml), TEA (5ml) and 10% Pd/C (200 mg). The vessel was placed on the par hydrogenator at 35 psi overnight. The Pd was filtered and the solvent removed to give 3-fluoro-4-[6-methoxy-7-(2-methyl-octahydro-cyclopenta[c]pyrrol-5-ylmethoxy)-quinolin-4-yloxy]-phenylamine as an off yellow solid (0.78 g, 99% yield). ^1H NMR (400 MHz, CDCl_3): 8.45 (d, 1H), 7.57 (s, 1H), 7.36 (s, 1H), 7.05 (t, 1H), 6.54 (m, 2H), 6.39 (d, 1H), 4.16 (d, 2H), 4.01 (s, 3H), 3.81 (m, 3H), 2.61 (m, 3H), 2.41 (m, 1H), 2.29 (s, 3H), 2.23 (m, 2H), 1.32 (m, 2H); MS (EI) for $\text{C}_{25}\text{H}_{28}\text{FN}_3\text{O}_3$: 438 ($\text{M}+\text{H}^+$).

Example 86



[0318] **5-[4-(4-Amino-2-fluoro-phenoxy)-6-methoxy-quinazolin-7-yloxymethyl]-hexahydrocyclopenta[c]pyrrole-2-carboxylic acid benzyl ester.** 4-Amino-2-fluoro-phenol (1.53g, 12.0mmol) was dissolved in dry DMF (30ml) to which was added 60% NaH (774mg, 19.3mmol). After the mixture was stirred at room temperature for several minutes, a suspension of 5-(4-chloro-6-methoxy-quinazolin-7-yloxymethyl)hexahydrocyclopenta[c]pyrrole-2-carboxylic acid benzyl ester (4.70g, 6.7mmol) in dry DMF (40ml) was added. The reaction mixture was stirred at room temperature for 1-2 hrs, then diluted with EtOAc and washed with sat'd NaHCO₃ (3x), H₂O (1x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in vacuo* to give crude 5-[4-(4-amino-2-fluoro-phenoxy)-6-methoxy-quinazolin-7-yloxymethyl]-hexahydro-cyclopenta[c]pyrrole-2-carboxylic acid benzyl ester (5.6g, ~100%) which was used in the next reaction without further purification. ¹H-NMR (400MHz, d₆-DMSO): 8.50 (s, 1H), 7.48 (s, 1H), 7.34 (m, 5H), 7.28 (m, 1H), 7.02 (t, 1H), 6.48 (dd, 1H), 6.40 (dd, 1H), 5.40 (br s, 2H), 5.05 (s, 2H), 4.16 (d, 2H), 3.92 (s, 3H), 3.48 (m, 2H), 3.30 (m, 2H), 2.65 (m, 2H), 2.52 (m, 1H), 2.10 (m, 2H), 1.30 (m, 2H). LC/MS Calcd for [M+H]⁺ 559.2, found 559.4.

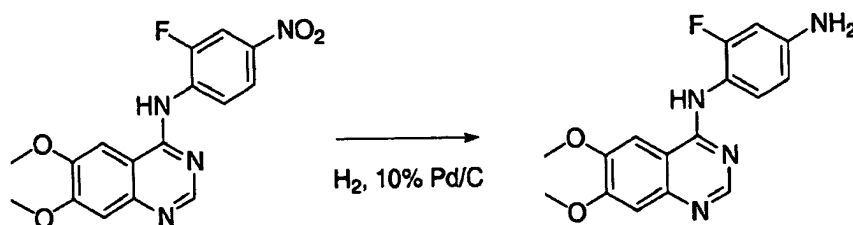
Example 87



[0319] **(6,7-Dimethoxy-quinazolin-4-yl)-(2-fluoro-4-nitro-phenyl)-amine.** A mixture of 4-chloro-6,7-dimethoxy-quinazoline (548mg, 2.4mmol), 2-fluoro-4-nitrophenylamine (392mg, 2.5mmol), AcCN (10ml), and conc'd HCl (0.050ml) was heated to reflux for several hrs.

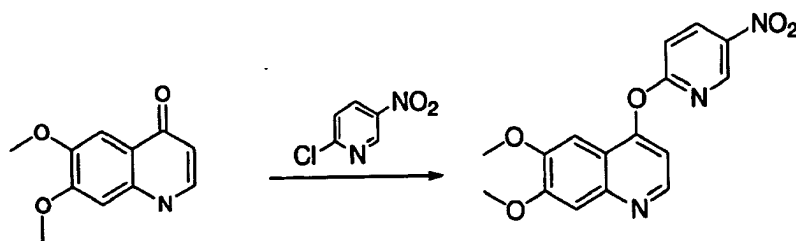
After the reaction mixture was allowed to cool to room temperature, the resulting solids were filtered, washed with AcCN and air-dried to give (6,7-dimethoxy-quinazolin-4-yl)-(2-fluoro-4-nitro-phenyl)-amine (673mgs, 80%). ¹H-NMR (400MHz, d₆-DMSO): 12.18 (br s, 1H), 8.91 (s, 1H), 8.45 (s, 1H), 8.36 (dd, 1H), 8.24 (dd, 1H), 7.91 (dd, 1H), 7.44 (s, 1H), 4.04 (s, 3H), 4.02 (s, 3H). LC/MS Calcd for [M+H]⁺ 345.1, found 345.4.

Example 88



[0320] **N¹-(6,7-Dimethoxy-quinazolin-4-yl)-2-fluoro-benzene-1,4-diamine.** (6,7-Dimethoxy-quinazolin-4-yl)-(2-fluoro-4-nitro-phenyl)-amine (673mg, 1.95mmol) was dissolved in a combination of DMF (20ml) and MeOH (20ml), to which was added 10% Pd/C (227mg). The mixture was shaken under an atmosphere of H₂ on a Parr hydrogenator at 40psi for 3hrs. The reaction mixture was filtered through celite and the filtrate concentrated *in vacuo*. The resulting residue was triturated in EtOAc/Et₂O. The resulting solids were filtered, washed with Et₂O, and dried under vacuum to give N¹-(6,7-dimethoxy-quinazolin-4-yl)-2-fluoro-benzene-1,4-diamine (398mg, 65%) which was used in the next reaction without further purification. ¹H-NMR (400MHz, d₆-DMSO): 10.80 (br s, 1H), 10.30 (br s, 1H), 8.63 (s, 1H), 8.15 (s, 1H), 7.33 (s, 1H), 7.15 (m, 1H), 6.45 (m, 1H), 3.96 (s, 6H). LC/MS Calcd for [M+H]⁺ 315.1, found 315.4.

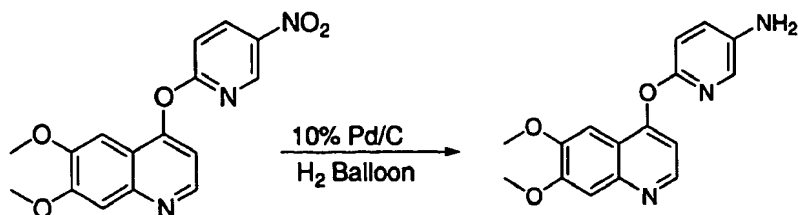
Example 89



[0321] **6,7-Dimethoxy-4-(5-nitro-pyridin-2-yloxy)-quinoline.** To a round bottom flask equipped with a magnetic stir bar was added 6,7-dimethoxy-1H-quinolin-4-one (1.8 g, 8.77

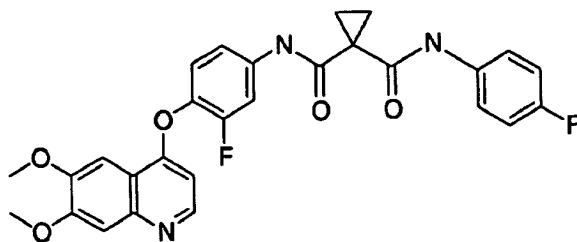
mmol, 1.0 eq.), anhydrous acetonitrile (90 mL) and Cs_2CO_3 (3.13 g, 9.65 mmole, 1.1 eq.). The reaction mixture was stirred at room temperature for 5 minutes. Then, 2-Cl-5-nitropyridine (1.53 g, 9.65 mmol, 1.1 eq.) was added. The reaction mixture was stirred at room temperature for 16 hours. The solids were then filtered off and the filtrate was concentrated via rotary evaporation. The resulting material was taken up in EtOAc, and again the solids were filtered off. The EtOAc filtrate was concentrated. Purification was done on Biotage with solvent system EtOAc 100%. The collected pure fractions were concentrated and dried on high vacuum overnight to give 6,7-dimethoxy-4-(5-nitro-pyridin-2-yloxy)-quinoline as a yellow foam solid (0.902 g, 31.4% yield). ^1H NMR (400 MHz, CDCl_3): 9.08 (d, 1H), 8.74 (d, 1H), 8.60 (dd, 1H), 7.49 (s, 1H), 7.26 (d, 1H), 7.16 (s, 1H), 7.07 (d, 1H), 4.06 (s, 3H), 3.95 (s, 3H); MS (EI) for $\text{C}_{16}\text{H}_{13}\text{N}_3\text{O}_5$: 328 ($\text{M}+\text{H}^+$).

Example 90



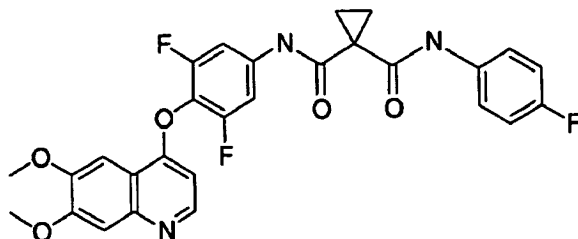
[0322] **6-(6,7-Dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine.** To a round bottom flask equipped with a magnetic stir bar was added 6,7-dimethoxy-4-(5-nitro-pyridin-2-yloxy)-quinoline (0.46 g, 1.41 mmol, 1.0 eq.), and THF (10 mL), MeOH (4 mL), DMF (2 mL), and TEA (2 mL). The 6,7-Dimethoxy-4-(5-nitro-pyridin-2-yloxy)-quinoline was dissolved completely in the above solution mixture, and was flushed with nitrogen for at least 5 minutes. The Pd/C (10% by weight) (0.090 g, 20% by weight) was then added. A balloon filled with H_2 was connected to the flask after the nitrogen was vacuumed out. The reaction mixture was stirred at room temperature for 4 hours. The palladium was filtered out through Celite, and the filtrate was collected and concentrated via rotary evaporation. The resulting oil-like product was taken up into 5 mL of water and 1 mL of acetonitrile and lyophilized to yield 6-(6,7-dimethoxy-quinolin-4-yloxy)-pyridin-3-ylamine as a light brown solid (0.411 g, 98.1%). ^1H NMR (400 MHz, CDCl_3): 8.54 (d, 1H), 7.85 (d, 1H), 7.53 (s, 1H), 7.41 (s, 1H), 7.18 (dd, 1H), 6.96 (d, 1H), 6.61 (d, 1H), 4.05 (s, 3H), 4.03 (s, 3H), 3.73 (s, 2H); MS (EI) for $\text{C}_{16}\text{H}_{15}\text{N}_3\text{O}_3$: 298 ($\text{M}+\text{H}^+$).

Example 91



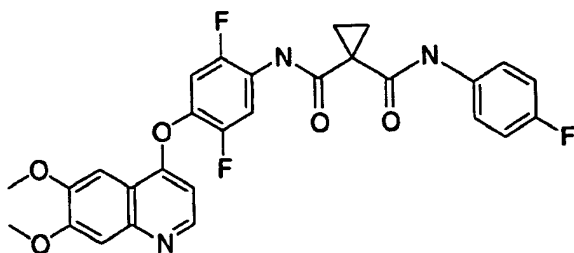
[0323] **N-(4-((6,7-bis(methoxy)quinolin-4-yl)oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared from 4-(6,7-dimethoxy-quinolin-4-yloxy)-3-fluoro-phenylamine and 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid, in an analogous manner to cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide. ^1H NMR (CDCl_3): 10.05 (s, 1H), 8.49 (d, 1H), 8.27 (s, 1H), 7.76 (d, 1H), 7.58 (s, 1H), 7.45 (s, 3H), 7.25 (m, 2H), 7.07 (t, 2H), 6.41 (d, 1H), 4.07 (s, 3H), 4.05 (s, 3H), 1.81 (s, 2H), 1.62 (s, 2H).

Example 92



[0324] **N-(4-((6,7-Bis(methoxy)quinolin-4-yl)oxy)-3,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared from 4-(6,7-dimethoxy-quinolin-4-yloxy)-3,5-difluoro-phenylamine and 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid, in an analogous manner to cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide. ^1H NMR (400 MHz, DMSO): 10.56 (s, 1H), 10.01 (s, 1H), 8.77 (d, 1H), 8.52 (m, 1H), 7.68 (m, 3H), 7.54 (s, 1H), 7.43 (s, 1H), 7.19 (t, 1H), 6.55 (d, 1H), 3.96 (s, 6H), 1.49 (d, 4H); MS (EI) for $\text{C}_{28}\text{H}_{22}\text{F}_3\text{N}_3\text{O}_5$: 538 (MH^+).

Example 93



[0325] **N-(4-([6,7-bis(methoxy)quinolin-4-yl]oxy)-2,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared from 4-(6,7-dimethoxy-quinolin-4-yloxy)-2,5-difluoro-phenylamine and 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid, in an analogous manner to cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide. ¹H NMR (400 MHz, DMSO): 11.15 (s, 1H), 9.79 (s, 1H), 8.55 (d, 1H), 8.17 (m, 1H), 7.64 (m, 3H), 7.54 (s, 1H), 7.51 (s, 1H), 7.39 (s, 1H), 7.16 (m, 2H), 6.54 (d, 1H), 3.95 (s, 6H), 1.66 (dd, 4H); MS (EI) for C₂₈H₂₂F₃N₃O₅: 538 (MH⁺).

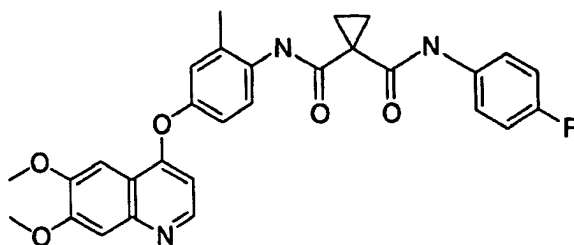
[0326] Using the same or analogous synthetic techniques and/or substituting with alternative starting materials, the following were prepared:

[0327] **N-(4-([6,7-bis(methoxy)quinolin-4-yl]oxy)-2,3,5-trifluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide:** ¹H NMR (400 MHz, DMSO): 8.52 (d, 1H), 8.10 (m, 1H), 7.61 (m, 2H), 7.54 (s, 1H), 7.44 (s, 1H), 7.19 (m, 2H), 6.69 (d, 1H), 3.96 (s, 6H), 1.62 (m, 4H).

[0328] **N-(4-([6,7-bis(methoxy)quinolin-4-yl]oxy)-5-fluoro-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide:** ¹H NMR (400 MHz, DMSO): 10.77 (s, 1H); 9.88 (s, 1H), 8.79 (d, 1H), 8.02 (d, 1H), 7.71 (s, 1H), 7.61 (m, 2H), 7.53 (s, 1H), 7.48 (d, 1H), 7.20 (t, 2H), 6.85 (d, 1H), 4.03 (d, 6H), 2.30 (s, 3H), 1.61 (m, 4H).

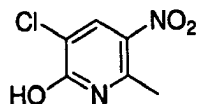
[0329] **N-(4-([6,7-bis(methoxy)quinolin-4-yl]oxy)-2-chloro-5-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide:** ¹H-NMR (400 MHz, CDCl₃) δ = 9.89 (s, 1H), 8.62 (m, 2H), 8.43 (s, 1H), 8.08 (s, 1H), 7.63 (s, 1H), 7.50 (m, 2H), 7.06 (t, *J* = 8.8 Hz, 2H), 6.58 (d, *J* = 6.0 Hz, 1H), 4.17 (s, 3H), 4.12 (s, 3H), 2.18 (s, 3H), 1.77 (m, 2H).

Example 94



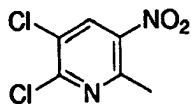
[0330] **N-(4-([6,7-bis(methoxy)quinolin-4-yl]oxy)-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared from 4-(6,7-dimethoxy-quinolin-4-yloxy)-2-methyl-phenylamine and 1-(4-fluoro-phenylcarbamoyl)-cyclopropanecarboxylic acid, in an analogous manner to cyclopropane-1,1-dicarboxylic acid [4-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-3-fluoro-phenyl]-amide (4-fluoro-phenyl)-amide. ^1H NMR (DMSO, d_6): 10.31 (s, 1H), 10.07 (s, 1H), 8.79 (d, 1H), 7.85 (d, 1H), 7.72 (s, 1H), 7.62 (m, 2H), 7.54 (s, 1H), 7.30 (s, 1H), 7.16 (m, 3H), 6.79 (d, 1H), 4.04 (s, 3H), 4.02 (s, 3H), 2.30 (s, 3H), 1.59 (m, 4H).

Example 95



[0331] **2-Hydroxy-3-chloro-5-nitro-6-picoline.** An aqueous solution of KClO_3 (1.12 g, 9.2 mmol) was added drop wise to an HCl solution (3.8 mL) of 2-hydroxy-5-nitro-6-picoline (3.56g, 23.1 mmol) at 55 °C over 15 mins. The reaction mixture was cooled to 0 °C and filtered. 2-hydroxy-3-chloro-5-nitro-6-picoline was isolated as a yellow solid (3.44g, 72%). MS (EI) for $\text{C}_6\text{H}_5\text{ClN}_2\text{O}_3$: 187 (MH $^+$).

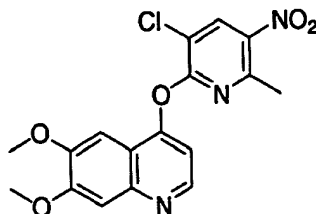
Example 96



[0332] **2,3-Dichloro-5-nitro-6-picoline.** A mixture of 3-chloro-5-nitro-6-picoline (4.77g, 25.4 mmol), phosphorous oxychloride (2.41 mL, 25.9 mmol), and phosphorous pentachloride were heated at 110 °C for 2 hours. The reaction mixture was cooled to ambient temperature

and poured into an ice/water mixture. 2,3-dichloro-5-nitro-6-picoline was isolated as a yellow solid (3.1g, 60%). MS (EI) for $C_6H_4Cl_2N_2O_2$: 205 (MH^+).

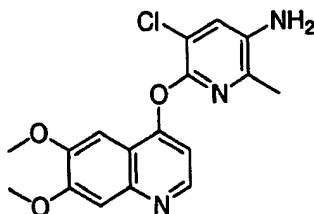
Example 97



[0333] **4-(3-Chloro-6-methyl-5-nitro-pyridin-2-yloxy)-6,7-dimethoxy-quinoline.** 6,7-

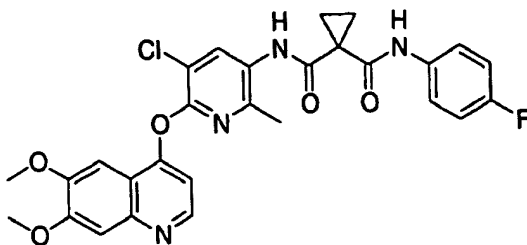
Dimethoxy-quinolin-4-ol (697 mg, 3.4 mmol), 2,3-dichloro-5-nitro-6-picoline (700 mg, 3.4 mmol), and cesium carbonate (1.22 g, 3.7 mmol) were slurried in acetonitrile (25 mL). The reaction mixture was heated at 50 °C under N_2 for 24 hours, after which time, the reaction mixture was cooled to ambient temperature. Filtration, concentration, and column chromatography on silica (ethylacetate) gave 4-(3-chloro-6-methyl-5-nitro-pyridin-2-yloxy)-6,7-dimethoxy-quinoline (128 mg, 10%). 1H NMR (400 MHz, $CDCl_3$): 8.74 (d, 5.1 Hz, 1H), 8.58 (s, 1H), 7.49 (s, 1H), 7.27 (s, 1H), 7.21 (d, 5.1 Hz, 1H), 4.06 (s, 3H), 3.99 (s, 3H), 2.68 (s, 3H); MS (EI) for $C_{17}H_{14}ClN_3O_5$: 376 (MH^+).

Example 98



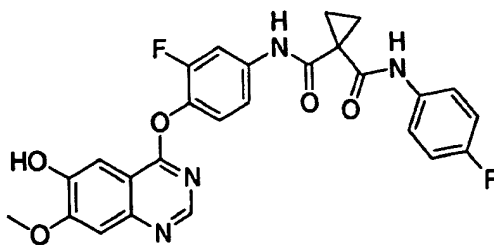
[0334] **5-Chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine.** 4-(3-Chloro-6-methyl-5-nitro-pyridin-2-yloxy)-6,7-dimethoxy-quinoline (128 mg, 0.34 mmol), platinum sulfide 5% wt on carbon, (16 mg), and ammonium formate (540 mg, 8.6 mmol) were slurried in ethanol (5 mL). The reaction mixture was heated at 80 °C for 2 hours, after which time, the reaction mixture was filtered through Celite. The solvent was removed *in vacuo* and the resultant yellow oil was extracted with EtOAc and water and dried with sodium sulfate. Filtration and concentration *in vacuo* gave 5-chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine (115 mg, 98%). MS (EI) for $C_{17}H_{16}ClN_3O_3$: 346 (MH^+).

Example 99



[0335] **N-(6-([6,7-Bis(methoxy)quinolin-4-yl]oxy)-5-chloro-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** 5-Chloro-6-(6,7-dimethoxy-quinolin-4-yloxy)-2-methyl-pyridin-3-ylamine (115 mg, 0.33 mmol), HATU (259 mg, 0.68 mmol), and TEA (0.17 mL, 1.2 mmol) were dissolved in DMF (5 mL). The reaction mixture was stirred at ambient temperature for 15 mins, after which time, 1-(4-fluorophenylcarbonyl)-cyclopropanecarboxylic acid (133 mg, 0.60 mmol) was added. The mixture was heated at 70 °C under N₂ for 24 hours. By LC/MS, *ca.* 50 % of the starting material was converted to the product and continued heating did not lead to more product formation. The reaction mixture was cooled to ambient temperature and diluted with water and ethyl acetate. The layers were separated and the organic layer was extracted 2x with 5% aqueous lithium chloride, 1x with brine, dried over sodium sulfate, filtered, and concentrated *in vacuo* to give a brown solid. This product was further purified by reverse phase preparatory HPLC eluting with gradient solvent system starting at 20% acetonitrile/25 mM NH₄OAc. After lyophilization, the product was isolated as a yellow solid (9.5 mg, 20%). ¹H NMR (400 MHz, *d*₆-DMSO): 10.36 (m, 1H), 9.97 (m, 1H), 8.51 (d, 5.3 Hz, 1H), 8.32 (m, 1H), 7.56 (m, 2H), 7.36 (s, 1H), 7.31 (m, 1H), 7.13-7.08 (m, 2H), 6.78 (d, 4.9 Hz, 1H), 3.89 (4, 3H), 3.83 (s, 3H), 2.34 (s, 3H) 1.50-1.48 (m, 4H); MS (EI) for C₂₈H₂₄ClFN₄O₅: 551 (MH⁺).

Example 100

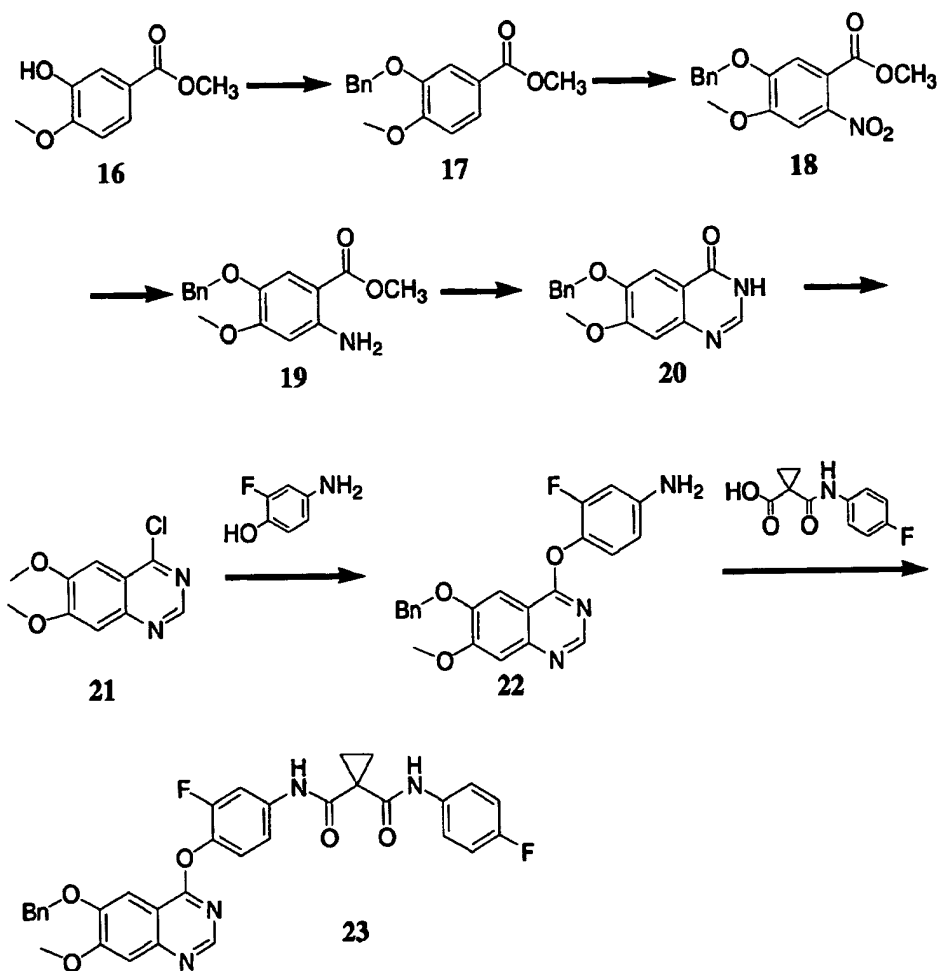


[0336] **Cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluorophenyl)-amide.** This compound was made in

an analogous manner to cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(7-hydroxy-6-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide. LC/MS Calcd for $[M+H]^+$ 507.1, found 507.2.

[0337] As additional reference, Scheme 3 outlines the synthesis of cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide.. This synthetic route can be used for synthesis of other 6-hydroxy-7-alkoxy-quinazolines, as would be readily understood by one of ordinary skill in the art.

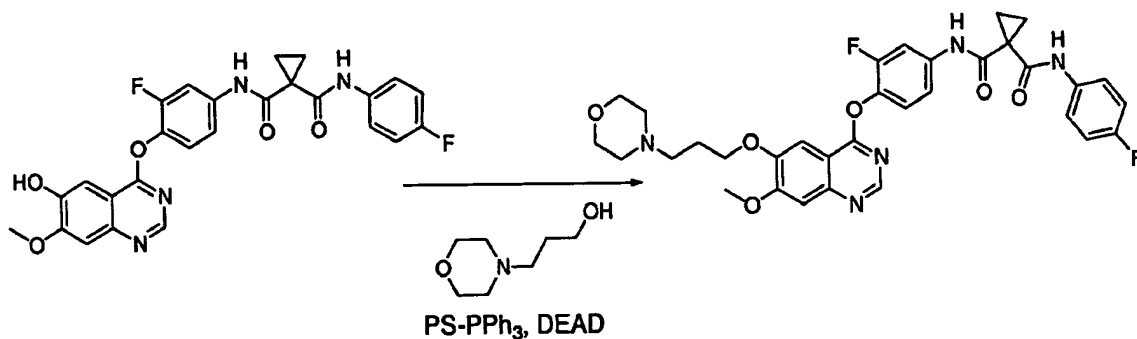
Scheme 3



[0338] Referring to Scheme 3, phenol 16 is protected as the benzyl ether, for example, to give intermediate 17. Intermediate 17 is regiospecifically nitrated to give 18, and then the nitro group is reduced to give aniline 19. Standard chemistry, as described herein for example, is used to convert 19 to the corresponding quinazolinone 20, which is dehydrated to give 4-chloroquinazoline 21. Quinazoline 21 is reacted with a phenol, for example, to make 22,

which in turn is coupled with an acid, for example as shown, via its amino group to form **23**. Cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide is made via removal of the benzyl ether of **23**. The 6-hydroxy group of cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide, is alkylated with various groups as described herein to make further exemplary compounds of the invention. For example, N-[3-Fluoro-4-((7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide, as depicted in example 101 below, can be made in this way. One of ordinary skill in the art would understand that there are other routes to such compounds and alternative methods for achieving the conversions described in Scheme 3.

Example 101



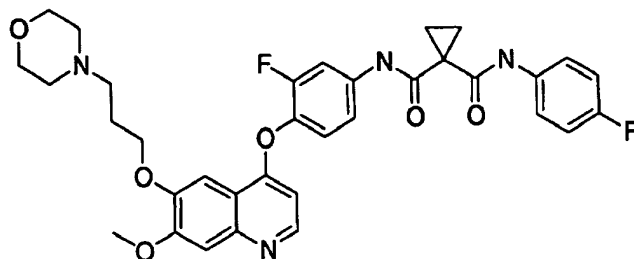
[0339] N-[3-Fluoro-4-((7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide. Crude cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinazolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide (333mg, 0.66mmol), PS-PPh₃ resin, (loading = 2.33mmol/g, 797mg, 1.86mmol), 3-morpholin-4-yl-propan-1-ol (0.26ml, 1.88mmol), and DEAD (0.31ml, 1.91mmol) were combined in CH₂Cl₂ (10ml) and stirred at room temperature for 1-2hrs. The reaction mixture was filtered and the resin thoroughly washed with CH₂Cl₂. The filtrate was concentrated *in vacuo* and the resulting residue was dissolved in EtOAc and washed with H₂O (4x) and sat'd NaCl (1x) and then extracted with 1N HCl (3x). The combined 1N HCl extractions were washed with EtOAc (2x). The acidic aqueous phase was then basified with 1N NaOH and extracted with EtOAc (3x). The combined EtOAc extractions were washed with H₂O (1x), sat'd NaCl (1x), dried (Na₂SO₄), and concentrated *in*

vacuo. The resulting residue was purified by preparative reverse phase HPLC (25mM NH_4OAc /acetonitrile) and the pure fractions were lyophilized to give cyclopropane-1,1-dicarboxylic acid {3-fluoro-4-[7-methoxy-6-(3-morpholin-4-yl-propoxy)-quinazolin-4-yloxy]-phenyl}-amide (4-fluoro-phenyl)-amide (42.6mg, 10%). ^1H NMR (400MHz, $\text{DMSO}-d_6$): δ 10.37 (br s, 1H), 10.05 (br s, 1H), 8.55 (s, 1H), 7.84 (m, 1H), 7.65 (m, 2H), 7.58 (s, 1H), 7.43 (m, 3H), 7.16 (t, 2H), 4.27 (m, 2H), 4.00 (s, 3H), 3.60 (m, 6H), 2.39 (m, 4H), 1.99 (m, 2H), 1.47 (m, 4H). LC/MS Calcd for $[\text{M}+\text{H}]^+$ 634.2, found 634.1.

[0340] Using the same or analogous synthetic techniques and/or substituting with alternative starting materials, the following were prepared:

[0341] **N-{3-fluoro-4-[(7-(methoxy)-6-[(1-methylpiperidin-4-yl)methyl]oxy}quinazolin-4-yl]oxy}phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide:** ^1H NMR (400MHz, CDCl_3): δ 9.67 (s, 1H), 8.59 (s, 1H), 8.43 (s, 1H), 7.75 (d, 1H), 7.52 (s, 1H), 7.46 (m, 2H), 7.31 (s, 1H), 7.20 (m, 2H), 7.06 (t, 2H), 4.04 (d, 2H), 4.03 (s, 3H), 2.98 (d, 2H), 2.34 (s, 3H), 2.12-2.195 (m, 5H), 1.76 (m, 2H), 1.64 (m, 2H), 1.57 (m, 2H).

Example 102



[0342] **[N-{3-fluoro-4-[(7-(methoxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy}phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide.** This compound was prepared from cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxyquinolin-4-yloxy)-phenyl]-amide(4-fluoro-phenyl)-amide and 3-morpholin-4-yl-propan-1-ol, in an analogous manner to N-[3-fluoro-4-[(7-(methoxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl]oxy}phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide. ^1H NMR (400 MHz, CDCl_3): 9.99 (s, 1H), 8.48 (d, 1H), 8.13 (br. s, 1H), 7.77 (dd, 1H), 7.59 (s, 1H), 7.52-7.44 (m, 2H), 7.42 (s, 1H), 7.29-7.20 (m, 2H), 7.10-7.06 (m, 2H), 6.39 (d, 1H), 4.28 (t, 2H), 4.03 (s, 3H), 3.72 (t, 2H), 2.58 (t, 2H), 4.29 (m, 4H), 2.14 (m, 2H), 1.82 (dd, 2H), 1.61 (dd, 2H); LC/MS Calcd for $[\text{M}+\text{H}]^+$ 633.2, found 633.1.

[0343] Using the same or analogous synthetic techniques and/or substituting with alternative starting materials, the following were prepared:

[0344] **N-(3-fluoro-4-([6-hydroxy-7-(methyloxy)quinolin-4-yl]oxy)phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide:** ¹H NMR (400 MHz, DMSO-d₆) 11.125 (br, 1H), 10.524 (br, 1H), 10.026 (br, 1H), 8.762-8.746 (d, 1H), 7.990-7.956 (dd, 1H), 7.7 (s, 1H), 7.665-7.63 (m, 2H), 7.6 (s, 1H), 7.578-7.517 (m, 2H), 7.185-7.163 (m, 2H), 6.864-6.848 (d, 1H), 4.041 (s, 3H), 1.503-1.465 (m, 4H).

[0345] **N-[5-fluoro-2-methyl-4-((6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide:** ¹H-NMR (400MHz, CDCl₃): δ 10.03 (s, 1H), 4.48 (d, 1H), 8.14 (s, 1H), 8.07 (d, 1H), 7.56 (s, 1H), 7.46 (m, 2H), 7.43 (s, 1H), 7.08 (m, 3H), 6.41 (dd, 1H), 4.27 (t, 2H), 4.04 (s, 3H), 3.73 (m, 4H), 2.58 (t, 2H), 2.49 (m, 4H), 2.34 (s, 3H), 2.13 (m, 2H), 1.85 (m, 2H), 1.63 (m, 2H).

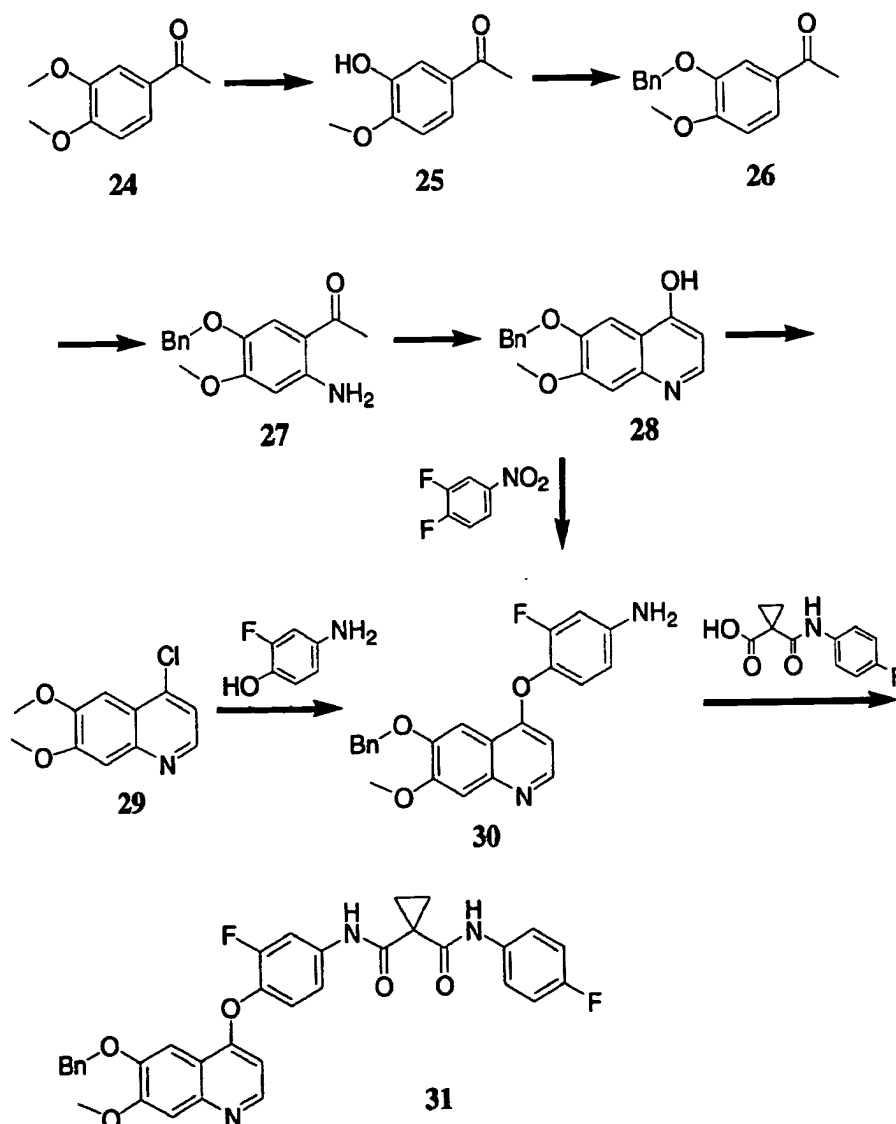
[0346] **N-(4-fluorophenyl)-N'-[2-methyl-4-((6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy)phenyl]cyclopropane-1,1-dicarboxamide:** ¹H NMR (400 MHz, CDCl₃) 9.032 (br, 1H), 8.926 (br, 1H), 8.485-8.472 (d, 1H), 7.875-7.851 (d, 1H), 7.523 (s, 1H), 7.504-7.47 (m, 2H), 7.428 (s, 1H), 7.073-7.03 (m, 4H), 6.484-6.471 (d, 1H), 4.291-4.257 (t, 2H), 4.029 (s, 3H), 3.741-3.717 (t, 4H), 2.597-2.579 (t, 2H), 2.489 (br, 4H), 2.343 (s, 3H), 2.155-2.120 (m, 2H), 1.747-1.715 (br, 4H).

[0347] As additional reference, Scheme 4 outlines the synthesis of synthesis of cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide.. This synthetic route can be used for synthesis of other 6-hydroxy-7-alkoxy-quinolines, as would be readily understood by one of ordinary skill in the art.

[0348] Referring to Scheme 4, dimethoxyaryl ketone **24** is converted to phenol **25** via regioselective removal of one of the methyl ethers. The free phenol of **25** is protected as the benzyl ether, for example, to give intermediate **26**. Intermediate **26** is regiospecifically nitrated, and then the nitro group is reduced to give aniline **27**. Standard chemistry, as described herein for example, is used to convert **27** to the corresponding 4-hydroxyquinoline **28**. Intermediate **28** can be converted to the corresponding 4-chloroquinoline **29**, which is reacted with, for example, a phenol, for example, to make **30**. Alternatively, 4-hydroxyquinoline is reacted with a 4-fluoronitrobenzene to give **30** directly. Aniline **30** is coupled with an acid, for example as shown, to form **31**. Cyclopropane-1,1-dicarboxylic acid

[3-fluoro-4-(6-hydroxy-7-methoxy-quinolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide is made via removal of the benzyl ether of 31. The 6-hydroxy group of cyclopropane-1,1-dicarboxylic acid [3-fluoro-4-(6-hydroxy-7-methoxy-quinolin-4-yloxy)-phenyl]-amide (4-fluoro-phenyl)-amide, is alkylated with various groups as described herein to make further exemplary compounds of the invention. For example, [N-[3-fluoro-4-({7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl}oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide, as depicted in example 102 above, can be made in this way. One of ordinary skill in the art would understand that there are other routes to such compounds and alternative methods for achieving the conversions described in Scheme 4.

Scheme 4



Assays

[0349] Kinase assays were performed by measurement of incorporation of γ - ^{33}P ATP into immobilized myelin basic protein (MBP). High binding white 384 well plates (Greiner) were coated with MBP (Sigma #M-1891) by incubation of 60 μl /well of 20 $\mu\text{g}/\text{ml}$ MBP in Tris-buffered saline (TBS; 50mM Tris pH 8.0, 138mM NaCl, 2.7mM KCl) for 24 hours at 4° C. Plates were washed 3X with 100 μl TBS. Kinase reactions were carried out in a total volume of 34 μl in kinase buffer (5mM Hepes pH 7.6, 15mM NaCl, 0.01% bovine gamma globulin (Sigma #I-5506), 10mM MgCl_2 , 1mM DTT, 0.02% TritonX-100). Compound dilutions were performed in DMSO and added to assay wells to a final DMSO concentration of 1%. Each data point was measured in duplicate, and at least two duplicate assays were performed for each individual compound determination. Enzyme was added to final concentrations of 10nM or 20nM, for example. A mixture of unlabeled ATP and γ - ^{33}P ATP was added to start the reaction (2x10⁶ cpm of γ - ^{33}P ATP per well (3000Ci/mmol) and either 10 μM or 30 μM unlabeled ATP, typically. The reactions were carried out for 1 hour at room temperature with shaking. Plates were washed 7x with TBS, followed by the addition of 50 μl /well scintillation fluid (Wallac). Plates were read using a Wallac Trilux counter. This is only one format of such assays, various other formats are possible, as known to one skilled in the art.

[0350] The above assay procedure can be used to determine the IC_{50} for inhibition and/or the inhibition constant, K_i . The IC_{50} is defined as the concentration of compound required to reduce the enzyme activity by 50% under the conditions of the assay. Exemplary compositions have IC_{50} 's of, for example, less than about 100 μM , less than about 10 μM , less than about 1 μM , and further for example having IC_{50} 's of less than about 100 nM, and still further, for example, less than about 10 nM. The K_i for a compound may be determined from the IC_{50} based on three assumptions. First, only one compound molecule binds to the enzyme and there is no cooperativity. Second, the concentrations of active enzyme and the compound tested are known (i.e., there are no significant amounts of impurities or inactive forms in the preparations). Third, the enzymatic rate of the enzyme-inhibitor complex is zero. The rate (i.e., compound concentration) data are fitted to the equation:

$$V = V_{\max} E_0 \left[1 - \frac{(E_0 + I_0 + K_d) - \sqrt{(E_0 + I_0 + K_d)^2 - 4E_0 I_0}}{2E_0} \right]$$

where V is the observed rate, V_{\max} is the rate of the free enzyme, I_0 is the inhibitor concentration, E_0 is the enzyme concentration, and K_d is the dissociation constant of the enzyme-inhibitor complex.

Kinase specificity assays:

[0351] Kinase activity and compound inhibition are investigated using one or more of the three assay formats described below. The ATP concentrations for each assay are selected to be close to the Michaelis-Menten constant (K_M) for each individual kinase. Dose-response experiments are performed at 10 different inhibitor concentrations in a 384-well plate format. The data are fitted to the following four-parameter equation:

$$Y = \text{Min} + (\text{Max} - \text{Min}) / (1 + (X/IC_{50})^H)$$

where Y is the observed signal, X is the inhibitor concentration, Min is the background signal in the absence of enzyme (0% enzyme activity), Max is the signal in the absence of inhibitor (100% enzyme activity), IC_{50} is the inhibitor concentration at 50% enzyme inhibition and H represents the empirical Hill's slope to measure the cooperativity. Typically H is close to unity.

c-Met Assay

[0352] c-Met biochemical activity was assessed using a Luciferase-Coupled Chemiluminescent Kinase assay (LCCA) format as described above. Again, kinase activity was measured as the percent ATP remaining following the kinase reaction. Remaining ATP was detected by luciferase-luciferin-coupled chemiluminescence. Specifically, the reaction was initiated by mixing test compounds, 1 μ M ATP, 1 μ M poly-EY and 10nM c-Met (baculovirus expressed human c-Met kinase domain P948-S1343) in a 20uL assay buffer (20mM Tris-HCL pH7.5, 10mM MgCl₂, 0.02% Triton X-100, 100mM DTT, 2mM MnCl₂). The mixture is incubated at ambient temperature for 2hours after which 20uL luciferase-luciferin mix is added and the chemiluminescent signal read using a Wallac Victor² reader. The luciferase-luciferin mix consists of 50 mM HEPES, pH 7.8, 8.5ug/mL oxalic acid (pH

7.8), 5 (or 50) mM DTT, 0.4% Triton X-100, 0.25 mg/mL coenzyme A, 63 μ M AMP, 28 μ g/mL luciferin and 40,000 units of light/mL luciferase.

KDR Assay

[0353] KDR biochemical activity was assessed using a Luciferase-Coupled Chemiluminescent Kinase assay (LCCA) format. Kinase activity was measured as the percent ATP remaining following the kinase reaction. Remaining ATP was detected by luciferase-luciferin-coupled chemiluminescence. Specifically, the reaction was initiated by mixing test compounds, 3 μ M ATP, 1.6 μ M poly-EY and 5 nM KDR (baculovirus expressed human KDR kinase domain D807-V1356) in a 20 μ L assay buffer (20mM Tris-HCL pH7.5, 10mM MgCl₂, 0.01% Triton X-100, 1mM DTT, 3mM MnCl₂). The mixture is incubated at ambient temperature for 4 hours after which 20 μ L luciferase-luciferin mix is added and the chemiluminescent signal read using a Wallac Victor² reader. The luciferase-luciferin mix consists of 50 mM HEPES, pH 7.8, 8.5 μ g/mL oxalic acid (pH 7.8), 5 (or 50) mM DTT, 0.4% Triton X-100, 0.25 mg/mL coenzyme A, 63 μ M AMP, 28 μ g/mL luciferin and 40,000 units of light/mL luciferase.

flt-4 Assay

[0354] Biochemical activity for flt-4 was assessed using an Alphascreen Tyrosine Kinase protocol. AlphaScreenTM (Perkin Elmer) technology is a proximity assay employing microparticles. Singlet oxygen derived from a donor bead following laser excitation results in chemiluminescence when in proximity (100 Å) to an acceptor bead due to biomolecular interactions. For the Flt-4 assay, donor beads coated with streptavidin and acceptor beads coated with PY100 anti-phosphotyrosine antibody were used (Perkin Elmer). Biotinylated poly(Glu,Tyr) 4:1 (Perkin Elmer) was used as the substrate. Substrate phosphorylation was measured by addition of donor/acceptor beads by chemiluminescence following donor-acceptor bead complex formation. Test compounds, 5 μ M ATP, 3 nM biotinylated poly(Glu, Tyr) and 1 nM Flt-4 (baculovirus expressed human Flt-4 kinase domain D725-R1298) were combined in a volume of 20 μ L in a 384-well white, medium binding microtiter plate (Greiner). Reaction mixtures were incubated for 1 hr at ambient temperature. Reactions were

quenched by addition of 10 μ L of 15-30 mg/mL AlphaScreen bead suspension containing 75 mM Hepes, pH 7.4, 300 mM NaCl, 120 mM EDTA, 0.3% BSA and 0.03% Tween-20. After 2-16 hr incubation at ambient temperature plates were read using an AlphaQuest reader (Perkin Elmer). IC₅₀ values correlate well with those determined by radiometric assays.

flt-3 Assay

[0355] Biochemical activity for flt-3 was assessed using a Luciferase-Coupled Chemiluminescent Kinase assay (LCCA) format. Kinase activity was measured as the percent ATP remaining following the kinase reaction. Remaining ATP was detected by luciferase-luciferin-coupled chemiluminescence. Specifically, the reaction was initiated by mixing test compounds, 5 μ M ATP, 3 μ M poly-EY and 5 nM Flt-3 (baculovirus expressed human Flt-3 kinase domain R571-S993) in a 20 μ L assay buffer (20mM Tris-HCL pH7.5, 10mM MgCl₂, 0.01% Triton X-100, 1mM DTT, 2mM MnCl₂). The mixture is incubated at ambient temperature for 3 hours after which 20 μ L luciferase-luciferin mix is added and the chemiluminescent signal read using a Wallac Victor² reader. The luciferase-luciferin mix consists of 50 mM HEPES, pH 7.8, 8.5 μ g/mL oxalic acid (pH 7.8), 5 (or 50) mM DTT, 0.4% Triton X-100, 0.25 mg/mL coenzyme A, 63 μ M AMP, 28 μ g/mL luciferin and 40,000 units of light/mL luciferase.

c-Kit Assay

[0356] c-Kit biochemical activity was assessed using AlphaScreen τ m (Perkin Elmer) technology, described above. Test compounds, ATP, biotinylated poly(Glu, Tyr) and c-Kit kinase were combined in a volume of 20 μ L in a 384-well white, medium binding microtiter plate (Greiner). Reaction mixtures were incubated for 1 hr at ambient temperature. Reactions were quenched by addition of 10 μ L of 15-30 mg/mL AlphaScreen bead suspension containing 75 mM Hepes, pH 7.4, 300 mM NaCl, 120 mM EDTA, 0.3% BSA and 0.03% Tween-20. After 16 hr incubation at ambient temperature plates were read using an AlphaQuest reader (Perkin Elmer).

Structure Activity Relationships

[0357] Table 2 shows structure activity relationship data for selected compounds of the invention. Inhibition is indicated as IC₅₀ with the following key: A = IC₅₀ less than 50 nM, B = IC₅₀ greater than 50 nM, but less than 500 nM, C = IC₅₀ greater than 500 nM, but less than 5000 nM, and D = IC₅₀ greater than 5,000 nM. Depending upon the functionality about the quinazoline or quinoline, exemplary compounds of the invention exhibit selectivity for any of c-Met, KDR, c-Kit, flt-3, and flt-4. Abbreviations for enzymes listed in Table 2 are defined as follows: c-Met refers to hepatocyte growth factor receptor kinase; KDR refers to kinase insert domain receptor tyrosine kinase; flt-4, fms-like tyrosine kinase-4, representative of the FLK family of receptor tyrosine kinases; c-Kit, also called stem cell factor receptor or steel factor receptor; and flt-3, fms-like tyrosine kinase-3. Empty cells in Table 2 indicate lack of data only.

Table 2

Entry	Compound Name	c-Met	KDR	c-Kit	flt-3	flt-4
1	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	B	A	B
2	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	C	C			
3	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(phenylmethyl)cyclopropane-1,1-dicarboxamide	A	C	B	B	B
4	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-phenylcyclopropane-1,1-dicarboxamide	A	B	B	A	
5	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
6	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-piperidin-1-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
7	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-piperidin-1-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	A	A	A	B	A

Table 2

Entry	Compound Name	c-Met	KDR	c-Kit	flt-3	flt-4
8	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(2-phenylethyl)cyclopropane-1,1-dicarboxamide	C	C			
9	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	C	B	C	B
10	N-{4-[(7-chloroquinolin-4-yl)oxy]-3-fluorophenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	C	C	B
11	N-{4-[(7-chloroquinolin-4-yl)oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	B	C	B
12	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
13	N-(4-[[6,7-bis(methyloxy)quinazolin-4-yl]oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
14	N-(4-[[6,7-bis(methyloxy)quinazolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	B	A	A
15	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
16	N-[5-chloro-6-((6-(methyloxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy)quinolin-4-yl)oxy]pyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	B	A	A
17	N-[5-chloro-6-((6-(methyloxy)-7-[(piperidin-4-yl)methyl]oxy)quinolin-4-yl)oxy]pyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
18	N-[5-chloro-6-((6-(methyloxy)-7-[(phenylmethyl)oxy]quinolin-4-yl)oxy)pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	C	C	B	C
19	N-(4-[[7-[[2-(diethylamino)ethyl]oxy]-6-(methyloxy)quinolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
20	N-(4-[[7-[[2-(diethylamino)ethyl]oxy]-6-(methyloxy)quinolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	A	A	A	B	A

Table 2

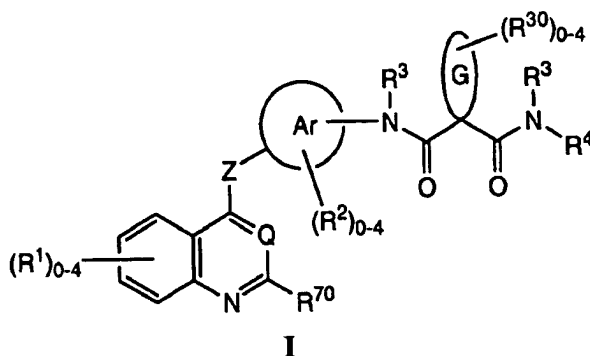
Entry	Compound Name	c-Met	KDR	c-Kit	flt-3	flt-4
21	N-{3-fluoro-4-[(6-(methyloxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy)quinazolin-4-yl]oxy}phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
22	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	C	A
23	N-(4-fluorophenyl)-N'-[2-methyl-6-[(6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy]pyridin-3-yl]cyclopropane-1,1-dicarboxamide	A	A	B	B	B
24	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A	A	A	A
25	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloro-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	C			
26	N-[3-fluoro-4-[(7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl]oxy]phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
27	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-3,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
28	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
29	N-[3-fluoro-4-[(7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy]phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
30	N-{3-fluoro-4-[(7-(methyloxy)-6-[(1-methylpiperidin-4-yl)methyl]oxy)quinazolin-4-yl]oxy}phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
31	N-[5-fluoro-2-methyl-4-[(6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy]phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
32	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2,3,5-trifluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
33	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-fluoro-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	B			

Table 2

Entry	Compound Name	c-Met	KDR	c-Kit	flt-3	flt-4
34	N-(4-([6,7-bis(methyloxy)quinolin-4-yl]oxy)-2-chloro-5-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	B			
35	N-(3-fluoro-4-([6-hydroxy-7-(methyloxy)quinolin-4-yl]oxy}phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	A	A			
36	N-(4-fluorophenyl)-N'-[2-methyl-4-([6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl]oxy}phenyl]cyclopropane-1,1-dicarboxamide	A	A			

What is claimed is:

1. A compound for modulating kinase activity according to Formula I,



or a pharmaceutically acceptable salt, hydrate, or prodrug thereof, wherein,

each R^1 is independently selected from halogen, $-OR^3$, $-NO_2$, $-NH_2$, $-NR^3R^4$, $-D-R^{50}$ and optionally substituted C_{1-6} alkyl;

R^{70} is selected from $-H$, halogen, $-OR^3$, $-S(O)_{0-2}R^3$, $-NO_2$, $-NH_2$, $-NR^3R^4$, and optionally substituted C_{1-6} alkyl;

Q is selected from $=N-$, $=C(H)-$, and $=C(CN)-$;

Z is selected from $-S(O)_{0-2}-$, $-O-$, and $-NR^5-$;

Ar is either a five- or six-membered arylene or a five- or six-membered heteroarylene containing between one and three heteroatoms;

G is either an optionally substituted cycloalkyl or an optionally substituted heteroalicyclic;

each R^2 is independently selected from halogen, trihalomethyl, $-CN$; $-NO_2$, $-NH_2$, $-OR^3$, $-NR^3R^4$, $-S(O)_{0-2}R^3$, $-SO_2NR^3R^3$, $-CO_2R^3$, $-C(O)NR^3R^3$, $-N(R^3)SO_2R^3$, $-N(R^3)C(O)R^3$, $-N(R^3)CO_2R^3$, $-C(O)R^3$, and optionally substituted C_{1-6} alkyl;

each R^3 is independently $-H$ or R^4 ;

each R^4 is independently selected from optionally substituted C_{1-6} alkyl, optionally substituted aryl, optionally substituted aryl C_{1-6} alkyl, optionally substituted heterocyclyl, and optionally substituted heterocyclyl C_{1-6} alkyl; or

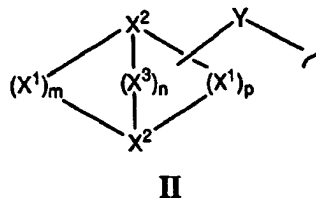
R^3 and R^4 , when taken together with a common nitrogen to which they are attached, form an optionally substituted five- to seven-membered heterocyclyl, said optionally substituted five-

to seven-membered heterocyclyl optionally containing at least one additional annular heteroatom selected from N, O, S, and P;

R^5 is -H or optionally substituted C_{1-6} alkyl;

each D is independently selected from -O-, $-S(O)_{0-2}-$, and $-NR^5-$;

each R^{50} is independently either R^3 , or according to formula II;



wherein X^1 , X^2 , and optionally X^3 , represent the atoms of a saturated bridged ring system, said saturated bridged ring system comprising up to four annular heteroatoms represented by any of X^1 , X^2 , and X^3 ; wherein,

each X^1 is independently selected from $-C(R^6)R^7-$, -O-, $-S(O)_{0-2}-$, and $-NR^8-$;

each X^2 is independently an optionally substituted bridgehead methine or a bridgehead nitrogen;

each X^3 is independently selected from $-C(R^6)R^7-$, -O-, $-S(O)_{0-2}-$, and $-NR^8-$;

Y is either:

an optionally substituted lower alkylene linker, between D and either 1) any annular atom of the saturated bridged ring system, except X^2 when X^2 is a bridgehead nitrogen, or 2) any heteroatom, represented by any of R^6 or R^7 ; provided there are at least two carbon atoms between D and any annular heteroatom of the saturated bridged ring system or any heteroatom represented by any of R^6 or R^7 ;

or Y is absent, when Y is absent, said saturated bridged ring system, is directly attached to D via an annular carbon of said saturated bridged ring system, unless D is $-SO_2-$, in which case said saturated bridged ring system, is directly attached to D via an any annular atom of said saturated bridged ring system;

m and p are each independently one to four;

n is zero to two, when n equals zero, then there is a single bond between the two bridgehead X^2 's;

R^6 and R^7 are each independently selected from -H, halogen, trihalomethyl, -CN, -NH₂, -NO₂, -OR³, -NR³R⁴, -S(O)₀₋₂R⁴, -SO₂NR³R⁴, -CO₂R³, -C(O)NR³R⁴, -N(R³)SO₂R⁴, -N(R³)C(O)R³, -NCO₂R³, -C(O)R³, optionally substituted C₁₋₆alkyl, optionally substituted aryl, optionally substituted aryl C₁₋₆alkyl, optionally substituted heterocyclyl, optionally substituted heterocyclyl C₁₋₆alkyl, and a bond to either Y or D; or

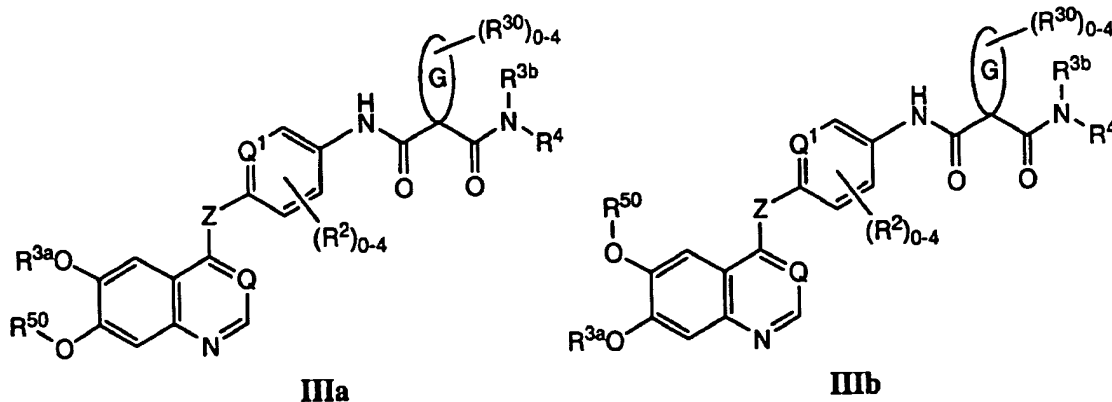
R^6 and R^7 , when taken together are oxo; or

R^6 and R^7 , when taken together with a common carbon to which they are attached, form a optionally substituted three- to seven-membered spirocyclyl, said optionally substituted three- to seven-membered spirocyclyl optionally containing at least one additional annular heteroatom selected from N, O, S, and P;

R^8 is selected from -R³, Y, -SO₂NR³R⁴, -CO₂R⁴, -C(O)NR³R³, -SO₂R⁴, and -C(O)R³; and

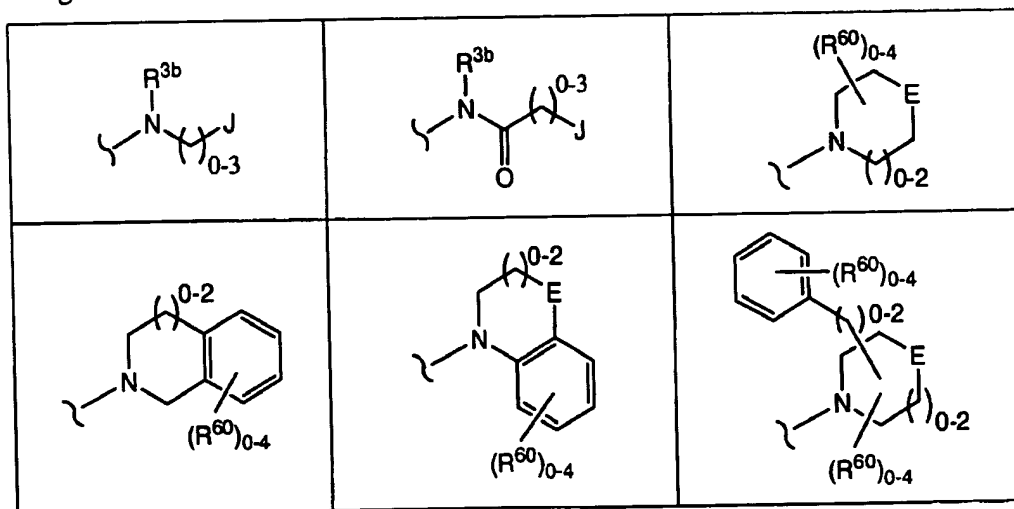
each R^{30} is independently selected from halogen, trihalomethyl, -CN, -NO₂, -NH₂, -OR³, -NR³R⁴, -S(O)₀₋₂R³, -SO₂NR³R³, -CO₂R³, -C(O)NR³R³, -N(R³)SO₂R³, -N(R³)C(O)R³, -N(R³)CO₂R³, -C(O)R³, and optionally substituted C₁₋₆alkyl.

2. The compound according to claim 1, wherein Z is either -O- or -NR⁵-.
3. The compound according to claim 2, wherein at least one of R^1 is -D-R⁵⁰.
4. The compound according to claim 3, wherein D is -O- and at least one other R^1 is -OR³.
5. The compound according to claim 4, of formula IIIa or IIIb:



wherein Q^1 is either =N- or =C(H)-.

6. The compound according to claim 5, wherein R^{50} is selected from C_{1-6} alkyl optionally substituted with at least one of optionally substituted amino, optionally substituted C_{1-6} alkyl amino, optionally substituted C_{1-6} dialkyl amino, optionally substituted heteroalicyclic, and a group of formula II.
7. The compound according to claim 6, wherein R^{3a} is C_{1-6} alkyl.
8. The compound according to claim 7, wherein Z is -O-.
9. The compound according to claim 8, wherein G is cyclopropyl, optionally substituted with between zero and four of R^{30} .
10. The compound according to claim 9, wherein Q is either =N- or =C(H)-.
11. The compound according to claim 10, wherein at least one of R^2 is halogen.
12. The compound according to claim 10, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
13. The compound according to claim 10, wherein $-N(R^{3b})R^4$ is selected from the following:



wherein J, is a five- to ten-membered ring, optionally substituted with between zero and five of R^{20} ;

each R^{20} is independently selected from halogen, trihalomethyl, -CN, -NO₂, -NH₂, -OR³, -NR³R⁴, -S(O)₀₋₂R³, -SO₂NR³R³, -CO₂R³, -C(O)NR³R³, -N(R³)SO₂R³, -N(R³)C(O)R³, -N(R³)CO₂R³, -C(O)R³, and optionally substituted C_{1-6} alkyl;

E is selected from -O-, -N(R⁵)-, -CH₂-, and -S(O)₀₋₂-;

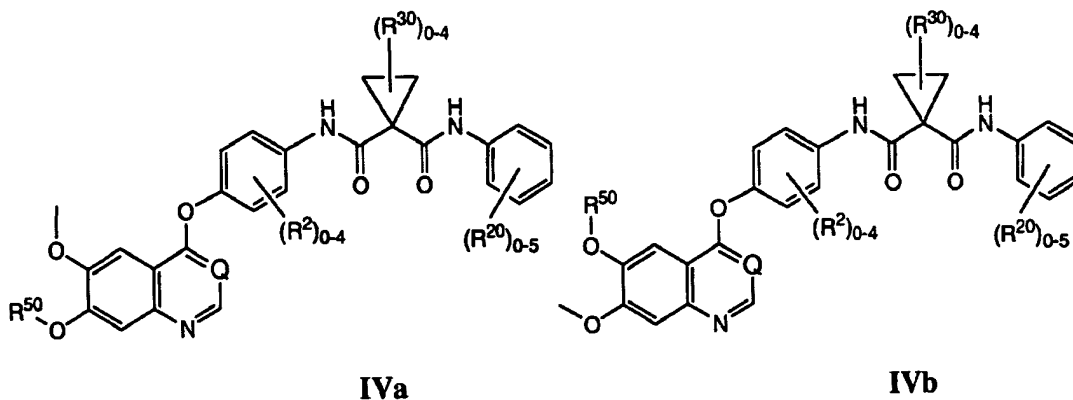
each R^{60} is independently selected from halogen, trihalomethyl, $-\text{CN}$, $-\text{NO}_2$, $-\text{NH}_2$, $-\text{OR}^3$, $-\text{NR}^3\text{R}^4$, $-\text{S(O)}_{0-2}\text{R}^3$, $-\text{SO}_2\text{NR}^3\text{R}^3$, $-\text{CO}_2\text{R}^3$, $-\text{C(O)NR}^3\text{R}^3$, $-\text{N(R}^3\text{)SO}_2\text{R}^3$, $-\text{N(R}^3\text{)C(O)R}^3$, $-\text{N(R}^3\text{)CO}_2\text{R}^3$, $-\text{C(O)R}^3$, optionally substituted C_{1-6} alkyl, optionally substituted aryl, optionally substituted heteroaryl C_{1-6} alkyl, and optionally substituted aryl C_{1-6} alkyl;

each methylene in any of the above formulae, other than those in a depicted ring, is independently optionally substituted with R^{25} ; and

R^{25} is selected from halogen, trihalomethyl, oxo, $-\text{CN}$, $-\text{NO}_2$, $-\text{NH}_2$, $-\text{OR}^3$, $-\text{NR}^3\text{R}^4$, $-\text{S(O)}_{0-2}\text{R}^3$, $-\text{SO}_2\text{NR}^3\text{R}^3$, $-\text{CO}_2\text{R}^3$, $-\text{C(O)NR}^3\text{R}^3$, $-\text{N(R}^3\text{)SO}_2\text{R}^3$, $-\text{N(R}^3\text{)C(O)R}^3$, $-\text{N(R}^3\text{)CO}_2\text{R}^3$, $-\text{C(O)R}^3$, optionally substituted aryl, optionally substituted aryl C_{1-6} alkyl, heteroaryl C_{1-6} alkyl, and optionally substituted C_{1-6} alkyl; or

two of R^{25} , together with the carbon or carbons to which they are attached, can combine to form a three- to seven-membered alicyclic or heteroalicyclic.

14. The compound according to claim 13, of formula IVa or IVb:



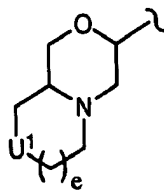
15. The compound according to claim 14, wherein R^{50} is C_{1-6} alkyl optionally substituted with an optionally substituted heteroalicyclic.

16. The compound according to claim 15, wherein the heteroalicyclic portion of said optionally substituted heteroalicyclic of R^{50} is selected from the group consisting of piperidine, piperazine, morpholine, thiomorpholine, thiomorpholine 1-oxide, thiomorpholine 1,1-dioxide, 2-oxo-morpholine, pyrrolidine, and azepine.

17. The compound according to claim 16, wherein at least one of R^2 is halogen.

18. The compound according to claim 16, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.

19. The compound according to claim 17, wherein at least one of R^{20} is halogen.
20. The compound according to claim 17, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.
21. The compound according to claim 14, wherein R^{50} is according to formula II.
22. The compound according to claim 21, wherein the saturated bridged ring system according to formula II has a geometry selected from the group consisting of [4.4.0], [4.3.0], [4.2.0], [4.1.0], [3.3.0], [3.2.0], [3.1.0], [3.3.3], [3.3.2], [3.3.1], [3.2.2], [3.2.1], [2.2.2], and [2.2.1].
23. The compound according to claim 22, wherein Y is selected from $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2-$, and absent.
24. The compound according to claim 23, wherein $n = 0$ and the saturated bridged ring system according to formula II has a geometry selected from the group consisting of [4.4.0], [4.3.0], [4.2.0], [4.1.0], [3.3.0], [3.2.0], and [3.1.0].
25. The compound according to claim 24, wherein said saturated bridged ring system contains at least one annular nitrogen or at least one annular oxygen.
26. The compound according to claim 25, wherein said saturated bridged ring system contains $-\text{NR}^8-$, wherein R^8 is selected from $-\text{H}$, optionally substituted C_{1-6} alkyl, $-\text{CO}_2\text{R}^3$, $-\text{C}(\text{O})\text{NR}^3\text{R}^3$, $-\text{SO}_2\text{R}^3$, and $-\text{C}(\text{O})\text{R}^3$.
27. The compound according to claim 25, wherein said saturated bridged ring system is of formula V,

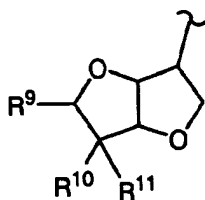


V

wherein U^1 is selected from $-\text{O}-$, $-\text{S}(\text{O})_{0-2}-$, $-\text{NR}^8-$, $-\text{CR}^6\text{R}^7-$, and absent; and e is 0 or 1.

28. The compound according to claim 27, wherein Y is $-\text{CH}_2-$.
29. The compound according to claim 28, wherein at least one of R^2 is halogen.

30. The compound according to claim 28, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
31. The compound according to claim 29, wherein at least one of R^{20} is halogen.
32. The compound according to claim 31, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.
33. The compound according to claim 28, wherein U^1 is $-NR^8-$, wherein R^8 is selected from $-H$, optionally substituted lower alkyl, $-CO_2R^3$, $-C(O)NR^3R^3$, $-SO_2R^3$, and $-C(O)R^3$.
34. The compound according to claim 28, wherein U^1 is $-O-$.
35. The compound according to claim 28, wherein U^1 is absent.
36. The compound according to claim 25, wherein Y is selected from $-CH_2CH_2-$, $-CH_2-$, and absent.
37. The compound according to claim 36, wherein said saturated bridged ring system is of formula VI,



VI

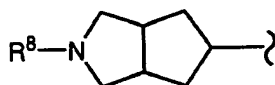
wherein R^9 , R^{10} , and R^{11} are each independently selected from $-H$, and $-OR^{12}$; or

R^9 is selected from $-H$, and $-OR^{12}$, and R^{10} and R^{11} , when taken together, are either an optionally substituted alkylidene or an oxo;

R^{12} is selected from $-H$, $-C(O)R^3$, optionally substituted lower alkylidyne, optionally substituted lower arylalkylidyne, optionally substituted lower heterocyclalkylidyne, optionally substituted lower alkylidene, optionally substituted lower alkylidenearyl, optionally substituted lower alkylideneheterocycl, optionally substituted lower alkyl, optionally substituted lower alkylaryl, optionally substituted aryl, optionally substituted lower heterocyclalkyl, and optionally substituted heterocycl;

or two R^{12} 's, when taken together, form 1) a corresponding spirocyclic ketal when said two R^{12} 's stem from R^{10} and R^{11} , or 2) a corresponding cyclic ketal when said two R^{12} 's stem from R^9 and one of R^{10} and R^{11} .

38. The compound according to claim 37, wherein at least one of R^2 is halogen.
39. The compound according to claim 37, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
40. The compound according to claim 38, wherein at least one of R^{20} is halogen.
41. The compound according to claim 40, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.
42. The compound according to claim 37, wherein one of R^{10} and R^{11} is $-OR^{12}$, wherein R^{12} is selected from $-H$, $-C(O)R^3$, and optionally substituted lower alkyl; and R^9 and the other of R^{10} and R^{11} are both $-H$.
43. The compound according to claim 42, wherein Y is either $-CH_2-$ or absent.
44. The compound according to claim 37, wherein R^9 is an alkyl group containing at least one fluorine substitution thereon.
45. The compound according to claim 26, wherein said saturated bridged ring system is of formula VII.



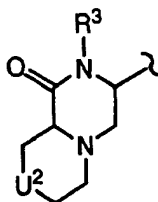
VII

46. The compound according to claim 45, wherein Y is either $-CH_2-$ or absent.
47. The compound according to claim 46, wherein R^8 is methyl or ethyl.
48. The compound according to claim 47, wherein at least one of R^2 is halogen.
49. The compound according to claim 47, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
50. The compound according to claim 48, wherein at least one of R^{20} is halogen.
51. The compound according to claim 50, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.

52. The compound according to claim 26, wherein said saturated bridged ring system is of formula **VIII**.

**VIII**

53. The compound according to claim 52, wherein Y is $-\text{CH}_2-$.
54. The compound according to claim 53, wherein R^8 is methyl or ethyl.
55. The compound according to claim 54, wherein at least one of R^2 is halogen.
56. The compound according to claim 54, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
57. The compound according to claim 55, wherein at least one of R^{20} is halogen.
58. The compound according to claim 57, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.
59. The compound according to claim 25, wherein said saturated bridged ring system is of formula **IX**

**IX**

wherein U^2 is selected from $-\text{O}-$, $-\text{S}(\text{O})_{0-2}-$, $-\text{NR}^8-$, $-\text{CR}^6\text{R}^7-$, and absent.

60. The compound according to claim 59, wherein R^3 of formula **IX** is selected from $-\text{H}$ and optionally substituted alkyl.
61. The compound according to claim 60, wherein U^2 is either $-\text{CR}^6\text{R}^7-$ or absent.
62. The compound according to claim 61, wherein U^2 is either $-\text{CH}_2-$ or absent.
63. The compound according to claim 62, wherein Y is $-\text{CH}_2-$.
64. The compound according to claim 63, wherein at least one of R^2 is halogen.

65. The compound according to claim 63, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
66. The compound according to claim 64, wherein at least one of R^{20} is halogen.
67. The compound according to claim 66, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.
68. The compound according to claim 26, wherein said saturated bridged ring system is according to formula X.



X

69. The compound according to claim 68, wherein R^8 is methyl or ethyl.
70. The compound according to claim 69, wherein at least one of R^2 is halogen.
71. The compound according to claim 69, wherein at least one of R^2 is C_{1-6} alkyl or perfluoro C_{1-6} alkyl.
72. The compound according to claim 70, wherein at least one of R^{20} is halogen.
73. The compound according to claim 72, wherein at least one of R^2 is fluoro and at least one of R^{20} is fluoro.
74. The compound according to claim 1, selected from the following:

Entry	Name	Structure
1	N-(6-[[6,7-bis(methoxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Entry	Name	Structure
2	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	
3	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-(phenylmethyl)cyclopropane-1,1-dicarboxamide	
4	N-(6-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-chloropyridin-3-yl)-N'-phenylcyclopropane-1,1-dicarboxamide	
5	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
6	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-piperidin-1-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
7	N-[3-fluoro-4-((6-(methyloxy)-7-[(3-piperidin-1-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	

Entry	Name	Structure
8	N-(6-([6,7-bis(methoxy)quinolin-4-yl]oxy)-5-chloropyridin-3-yl)-N'-(2-phenylethyl)cyclopropane-1,1-dicarboxamide	
9	N-(6-([6,7-bis(methoxy)quinolin-4-yl]oxy)-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
10	N-(4-[(7-chloroquinolin-4-yl)oxy]-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
11	N-(4-[(7-chloroquinolin-4-yl)oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
12	N-(4-([6,7-bis(methoxy)quinolin-4-yl]oxy)phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
13	N-(4-([6,7-bis(methoxy)quinazolin-4-yl]oxy)phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Entry	Name	Structure
14	N-(4-([6,7-bis(methoxy)quinazolin-4-yl]oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
15	N-[3-fluoro-4-((6-(methoxy)-7-[(3-morpholin-4-ylpropyl]oxy)quinazolin-4-yl]oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
16	N-[5-chloro-6-((6-(methoxy)-7-[(1-methylpiperidin-4-yl)methyl]oxy)quinolin-4-yl]oxy)pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
17	N-[5-chloro-6-((6-(methoxy)-7-[(piperidin-4-yl)methyl]oxy)quinolin-4-yl]oxy)pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
18	N-[5-chloro-6-((6-(methoxy)-7-[(phenylmethyl]oxy)quinolin-4-yl]oxy)pyridin-3-yl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
19	N-(4-([7-([2-(diethylamino)ethyl]oxy)-6-(methoxy)quinolin-4-yl]oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Entry	Name	Structure
20	N-(4-([7-([2-(diethylamino)ethyl]oxy)-6-(methoxy)quinolin-4-yl]oxy)-3-fluorophenyl)-N'-(4-fluorophenyl)cyclobutane-1,1-dicarboxamide	
21	N-{3-fluoro-4-[(6-(methoxy)-7-[[[1-methylpiperidin-4-yl)methyl]oxy]quinazolin-4-yl]oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
22	N-(4-{[6,7-bis(methoxy)quinolin-4-yl]oxy}-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
23	N-(4-fluorophenyl)-N'-[2-methyl-6-[(6-(methoxy)-7-[(3-morpholin-4-yl)propyl]oxy]quinolin-4-yl]oxy]pyridin-3-yl]cyclopropane-1,1-dicarboxamide	
24	N-(4-{[6,7-bis(methoxy)quinolin-4-yl]oxy}-3-fluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
25	N-(6-{[6,7-bis(methoxy)quinolin-4-yl]oxy}-5-chloro-2-methylpyridin-3-yl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Entry	Name	Structure
26	N-[3-fluoro-4-({7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinazolin-4-yl}oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
27	N-(4-{{6,7-bis(methyloxy)quinolin-4-yl}oxy}-3,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
28	N-(4-{{6,7-bis(methyloxy)quinolin-4-yl}oxy}-2,5-difluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
29	N-[3-fluoro-4-({7-(methyloxy)-6-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl}oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
30	N-{3-fluoro-4-[(6-(methyloxy)-7-(2-methyl octahydrocyclopenta[c]pyrrol-5-ylmethoxy)quinazolin-4-yl}oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
31	N-{3-fluoro-4-[(7-(methyloxy)-6-[(1-methylpiperidin-4-yl)methyl]oxy]quinazolin-4-yl}oxy]phenyl}-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Entry	Name	Structure
32	N-[5-fluoro-2-methyl-4-((6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl)oxy)phenyl]-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
33	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2,3,5-trifluorophenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
34	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-5-fluoro-2-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
35	N-(4-[[6,7-bis(methyloxy)quinolin-4-yl]oxy]-2-chloro-5-methylphenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	
36	N-(3-fluoro-4-[[6-hydroxy-7-(methyloxy)quinolin-4-yl]oxy]phenyl)-N'-(4-fluorophenyl)cyclopropane-1,1-dicarboxamide	

Entry	Name	Structure
37	N-(4-fluorophenyl)-N'-[2-methyl-4-({6-(methyloxy)-7-[(3-morpholin-4-ylpropyl)oxy]quinolin-4-yl)oxy]phenyl]cyclopropane-1,1-dicarboxamide	

75. A pharmaceutical composition comprising a compound according to any one of claims 1 - 74 and a pharmaceutically acceptable carrier.
76. A metabolite of the compound or the pharmaceutical composition according to any one of claims 1 - 75.
77. A method of modulating the *in vivo* activity of a kinase, the method comprising administering to a subject an effective amount of the compound or the pharmaceutical composition according to any of claims 1 - 75.
78. The method according to claim 77, wherein the kinase is at least one of c-Met, KDR, c-Kit, flt-3, and flt-4.
79. The method according to claim 77, wherein the kinase is c-Met.
80. The method according to claim 78, wherein modulating the *in vivo* activity of the kinase comprises inhibition of said kinase.
81. A method of treating diseases or disorders associated with uncontrolled, abnormal, and/or unwanted cellular activities, the method comprising administering, to a mammal in need thereof, a therapeutically effective amount of the compound or the pharmaceutical composition as described in any one of claims 1 - 75.
82. A method of screening for a modulator of a kinase, said kinase selected from c-Met, KDR, c-Kit, flt-3, and flt-4, the method comprising combining a compound according to any one of claims 1 - 74, and at least one candidate agent and determining the effect of the candidate agent on the activity of said kinase.

EX04-001P

83. A method of inhibiting proliferative activity in a cell, the method comprising administering an effective amount of a composition comprising a compound according any one of claims 1 - 74 to a cell or a plurality of cells.

ABSTRACT

The present invention provides compounds for modulating protein kinase enzymatic activity for modulating cellular activities such as proliferation, differentiation, programmed cell death, migration and chemoinvasion. More specifically, the invention provides quinazolines and quinolines which inhibit, regulate and/or modulate kinase receptor, particularly c-Met, KDR, c-Kit, flt-3 and flt-4, signal transduction pathways related to the changes in cellular activities as mentioned above, compositions which contain these compounds, and methods of using them to treat kinase-dependent diseases and conditions.

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